3.2 TRAVEL CONDITIONS

This section addresses the travel conditions related to different transportation modes in the study area. This section describes existing conditions and describes the potential of the No Project, Modal, and High-Speed Train (HST) Alternatives to affect travel conditions. Automobile and air transportation currently carry more than 98% of intercity trips, and are therefore the focus, together with the HST mode, of this section. For this analysis, *travel conditions* are defined as the experience, quality, sustainability, safety, reliability, and cost of intercity travel within the study area. Travel factors were developed based on the purpose and need (Chapter 1) for the proposed HST system and are used to evaluate the general impact of proposed changes to the transportation system for each of the alternatives.

3.2.1 Methods of Evaluation

A. METHOD OF EVALUATION OF IMPACTS

The overall method used to evaluate travel conditions is described below. To evaluate the relative differences in travel conditions that would result from implementation of the alternatives, six travel factors were considered that relate directly to the purpose and need and the goals and objectives defined in Chapter 1. These factors are listed below.

- Travel time.
- Reliability.
- Safety.
- Connectivity (both modal and geographic).
- Sustainable capacity.
- Passenger cost.

<u>Travel Time</u>
Travel time is the total time required to complete a journey. With the exception of the automobile, intercity transportation options require multiple modes to complete a trip. Most people acknowledge that an air trip is not just the time spent in the air (the line-haul portion of the trip), but also includes the time required to travel to the airport, check in, pass through security, board the plane, and travel to the final destination. The total travel time of a mode is also dependent on its reliability. If a mode is unreliable, a traveler must allow more time to complete a trip, effectively lengthening the total travel time.

<u>Reliability</u>
Reliability is the delivery of predictable and consistent travel times and is a key factor in attracting passengers to use a particular mode of travel. Travel time and reliability directly affect productivity, as they determine the ease and speed with which workers and products arrive at their destinations. Greater travel demand on capacity constrained facilities results in further congestion and is one of the primary reasons for longer travel times. Reliability is primarily a function of unexpected delays due to many factors, including traffic congestion, accidents, mechanical breakdowns, roadwork, and inclement weather.

<u>Safety</u>
Projected growth in the movement of people and goods in California by road and air underscores the need for improved travel safety. National and statewide statistics indicate that the rate of fatality or serious injury by private motor vehicle is increasing, primarily because more people are

traveling by this mode. Nationally, over the last 10 years, accident and injury rates have remained fairly constant for commercial airline travel, which remains a safe mode compared to the private automobile.

Connectivity (Modal and Geographic)
Modal: Connections between modes of transportation are an element in the development and operation of a successful total transportation system. The ability to transfer easily between modes and the frequency of service are additional key factors that can determine a traveler's modal choice. Statewide, connections between airports and the extensive regional urban and commuter transit systems are currently limited. Under existing conditions and No Project, modal connections at airports are limited, and the connections and services available are fragmented and not provided as an integrated system with coordinated fares, schedules, and amenities. With the exception of the new BART extension to San Francisco International Airport (SFO) and the Metrolink connection to Burbank Airport, other airports do not have direct rail connections to city centers, other transit systems, or the region. At these airports, transit connections can be cumbersome, often requiring multiple transfers and long waiting times, are not well advertised to potential passengers, and lack coordinated fares and schedules.

Geographic: Connecting the northern and southern urban areas of the state (southern California and San Francisco Bay Area) with an additional transportation system could significantly improve statewide mobility. Connecting these urban areas with the cities and communities of the Central Valley could yield potential benefits. Due to poor connectivity, limited services, and weather impacts, travel options to and from Central Valley cities are limited, travel times are long, and the potential for delay is high.

Sustainable Capacity
Sustainable capacity is a measure of the transportation system's capability to meet projected demand without the need to develop additional infrastructure. The current California transportation system is stressed beyond capacity in many places and for considerable periods of the day. Rush "hour" is a thing of the past. As demand increases without sufficient capacity, the severity of the congestion will increase and result in more frequent delays and longer peak travel periods throughout the day. This demand-capacity imbalance will worsen over time as system use increases. As a result, the transportation system will lose the ability to absorb short-term or long-term demand increases and become increasingly inflexible because of the lack of capacity. Indeed, travelers are already witnessing this phenomenon on many of California's major highways and at its major airports. US-101 between SFO and Redwood City is typically congested beyond traditional peak periods, and Los Angeles International Airport (LAX) regularly suffers significant flight delays due to congested conditions for arriving or departing flights.

Cost
Direct, passenger-borne costs are another key factor in passenger travel choice. Most travel demand studies have found that travel costs are highly variable, depending on the type of traveler and the purpose of travel. Business travelers may be willing to pay high fares for urgent needs, but leisure travelers may constrain themselves to the lowest fare possible. In some cases, travelers are also willing to pay a premium for a reliable, comfortable, and safe journey.

The six travel factors are summarized in Table 3.2-1. These travel factors are used to evaluate the relative difference between alternatives both qualitatively and quantitatively. The method by which the travel factors have been applied to the alternatives is summarized in Table 3.2-2. Each of the travel factors is described in greater detail as they are applied in the potential environmental consequences of travel conditions discussion.

In general, the No Project and Modal Alternatives would include the same intercity travel modes that are available under existing conditions, which are the automobile, airplane, intercity bus, and conventional rail. The intent of the environmental analysis performed in this Program EIR/EIS is to broadly assess the highest potential level of impact. Therefore, the high-end forecasts for the HST (68 million trips) are used to describe the operations and required facilities for the proposed alternatives. However, in a few areas where the high-end forecast produced the lowest impacts or highest benefit, analysis of conditions based on the low-end HST forecast (42 million trips) is also included. Both the high- and the low-end include 10 million long-distance commute trips.

Table 3.2-1
Relation of Travel Factors and Purpose and Need/Objectives

	Travel Factors					
	Connectivity	Travel Time	Reliability	Safety	Sustainable Capacity	Passenger Cost
Project Purpose						
To improve intercity travel experience	X	X	X	X	X	
To maximize intermodal transportation opportunities	X	X				
To meet future intercity travel demand	X	X				
To increase efficiency of intercity transportation system	X		X		X	
To maximize use of existing transportation corridors	X		X			
To develop a practical and feasible transportation system by 2020 and in phases	X					X
To provide a sustainable reduction in travel time		X			X	
Project Need						
Limited modal connections	X	X				
Future growth in travel demand					X	
Capacity constraints			X		X	
Unreliability of travel			X	X	X	
Project Goals and Objectives						
Maximize mobility	X				X	X
Minimize travel times		X				
Minimize environmental impacts					X	
Maximize system safety			X	X		
Maximize reliability			X			

X = Directly applies.
Source: Parsons Brinckerhoff 2003.

Table 3.2-2
Transportation Factors

Typology	Description	Measurement
Travel Time	Total door-to-door travel time	Total travel time including access and in-vehicle times
Reliability	Ability and perception to arrive at the destination on-time	Accidents Inclement weather Transportation-related construction Volume variation Special events Traffic control devices and procedures Base capacity Vehicle availability
Safety	Loss of life or injury	Comparison of safety performance characteristics by mode (operator, vehicle, and environment)
Connectivity	Transportation options that connect to other systems and destinations	Modal Number of intermodal connections and options, and frequency of service provided by each alternative Geographic Connectivity between regions by mode
Sustainable capacity	Ability to accommodate additional demand beyond the design demand	Amount of additional infrastructure required to meet a threshold demand above and beyond the design demand
Passenger cost	One-way travel costs	Total costs including fares and other costs for intercity travel by mode
Source: Parsons Brinckerhoff 2003.		

3.2.2 Affected Environment

A. STUDY AREA DEFINED

This program-level analysis of travel conditions and potential impacts does not measure the specific potential impact on individual transportation facilities (e.g., a transit line, highway or airport). Rather, travel conditions have been evaluated for the total project area and regional level. Specific examples of representative travel conditions in a corridor or for a specific highway, airport, or rail facility are identified where possible. The study area for this analysis of travel conditions encompasses all five regions in the project area—Bay Area to Merced, Sacramento to Bakersfield, Bakersfield to Los Angeles, Los Angeles to San Diego via Inland Empire, and Los Angeles to San Diego via Orange County (LOSSAN).

B. GENERAL DISCUSSION OF TRAVEL CONDITIONS

For travel conditions, the affected environment is California's intercity travel network, which consists of three main components: highways, airports, and rail. Of these, automobiles and air transportation currently carry over 98% of intercity trips, and are therefore the focus of this section. Congestion in the affected environment is a serious concern, as shown in Figure 3.2-1. According to the Texas Transportation Institute, the urban areas of San Francisco and Los Angeles experience some of the most severe highway congestion and travel delays in the country (Shrank and Lomax 2002). Recent research by the Institute of Transportation Studies at the University of California, Berkeley, indicates that California airports generally experience the highest average air travel delays in the nation (Hansen et al. 2002). Although the main contributors to this congestion are local and commuter highway trips and transcontinental and international flights (at least at major airports such as SFO and LAX), intercity trips compete for the limited capacity on these overburdened facilities.

The highway system is congested near and around urban centers (e.g., San Francisco, Los Angeles, San Diego) and in rural and suburban communities (e.g., Central Valley) during both the morning and evening peak hours. The Los Angeles area has some of the worst travel delay—the extra time spent traveling because of congestion—in the country, according the Texas Transportation Institute (Shrank and Lomax 2002). According to San Francisco's Metropolitan Transportation Commission (MTC), seven out of ten of the most congested highway corridors in the Bay Area (including segments of I-880, I-580, and US-101) are key intercity routes in the Bay Area to Merced region (see Figure 3.2-2). Similarly, according to the San Joaquin Council of Governments, several major routes that traverse the Central Valley (I-5, I-205, I-580, SR-120, SR-99) are critical intercity links for passengers and goods traveling between northern and southern California. Section 3.1, *Traffic and Circulation,* of this Program EIR/EIS notes that several of these routes are currently operating during the peak periods at or near congested levels of operations. In fact, I-5 and SR-90 (key intercity routes assessed in this analysis) are designated by the California Department of Transportation (Caltrans) as "high emphasis focus routes" of critical importance to the movement of goods in California.

California's aviation system provides for intercity, domestic, and international travel. The aviation system is also a significant economic generator that fuels the state's economy. According to the Federal Highway Administration, in 2002 California's airports contributed to about 9% of the state's employment and total economic output (Federal Highway Administration 2003). According to Caltrans, in 2002 about 159 million passengers in California traveled by air, or about 12% of the national total. Seven California airports are ranked in the top 50 U.S. primary/commercial service airports. As shown in Table 3.2-3, all seven airports are located in one of the five regions considered in this analysis.

Table 3.2-3
California Airport National Rankings (2002)

Airport	U.S. Ranking	Region
Los Angeles (LAX)	3	Bakersfield to Los Angeles and Los Angeles to San Diego (via Inland Empire and Orange County)
San Francisco (SFO)	8	Bay Area to Merced
San Diego (SAN)	30	Los Angeles to San Diego (via Inland Empire and Orange County)
San Jose (SJC)	34	Bay Area to Merced
Oakland (OAK)	37	Bay Area to Merced
Sacramento (SMF)	44	Sacramento to Bakersfield
John Wayne/Orange County (SNA)	45	Los Angeles to San Diego via Orange County
Source: Aviation in California Fact Sheet, California Department of Transportation, Division of Aeronautics, 2002.		

The National Center of Excellence for Aviation Operations and Research predicted that demand at California airports, which dropped by as much as 33% after the September 11, 2001, terrorist attacks, will recover to 2000 levels in 2002 or 2003 or shortly thereafter (National Center of Aviation Operations and Research 2002). As a result, the seven major airports in Table 3.2-3 currently operating at or near capacity are all planning major improvements to accommodate existing and future projected demand. In 2000, almost 25% of all flight arrivals were delayed for 9 minutes or more, a number significantly higher than the national average (Hansen et al. 2002).

Congested airways are one source of passenger delay for intercity trips; congested highways are another. According to the California Transportation Commission, California's major airports suffer from poor ground access and severe congestion, which directly impacts international trade (California Transportation Commission 2000). As shown in Section 3.1, *Traffic and Circulation,* many of the highway segments and primary airport access routes to the study area airports have a level of service (LOS) of E and F. *Level of service* describes the condition of traffic flow, ranging from excellent conditions at LOS A to overloaded conditions at LOS F. LOS D is typically recognized as an acceptable service level in urban areas.

3.2.3 Environmental Consequences

A. EXISTING CONDITIONS VS. NO PROJECT ALTERNATIVE

The No Project Alternative includes programmed and funded transportation improvements to the existing transportation system that will be implemented and operational by 2020. The primary differences between existing conditions and the No Project Alternative are the increased level of intercity travel demand and the implementation of new infrastructure. Improvements (programmed and funded) focus on existing modes; therefore, the same modes of intercity transport will continue to be available. The programmed or funded transportation improvements assumed to be in operation by 2020 are not major system-wide capacity improvements (e.g., major new highway construction or widening, or additional runways) and will not result in a general improvement or stabilization of existing highway or air travel conditions across the study area. Connectivity is not expected to improve with the No Project Alternative because few major intermodal terminals are expected to be built over the next 20 years.

As described in Section 3.1, *Traffic and Circulation*, existing facilities are currently operating at congested levels of service at many locations, and traffic conditions are projected to deteriorate further under the No Project Alternative. Of the 68 intercity highway segments analyzed in Section 3.1, more than half are operating during the peak period at LOS F or a volume-to-capacity (V/C) ratio more than 1.0 under existing conditions. These conditions are expected to deteriorate further under the No Project Alternative. On average, across all five regions, V/C ratios could deteriorate by almost 40%, and each region could have more LOS F segments under the No Project Alternative. Capacity in the No Project Alternative is insufficient to accommodate the projected growth in highway travel in every region, including both the traditional urban areas (e.g., the San Francisco Bay Area and Los Angeles basin) and the emerging urban areas in the Central Valley. Consequently, there would be no sustainable improvement to the transportation system's capacity.

Although intercity travel is only a small percentage of all highway trips, it must compete for limited capacity on already congested infrastructure for which insufficient capacity improvement projects are planned to be operational by 2020. For instance, according to MTC, between years 2000 and 2020 in the Bay Area, total vehicles per household will increase by 5%, and average vehicle miles traveled per weekday will increase by about 30%. This projection is representative of conditions throughout the state (Metropolitan Transportation Commission 2003). In the Central Valley, the San Joaquin Council of Governments estimates that the percentage of time vehicles are delayed relative to the total travel time will increase in 2025, and that the percentage of miles traveled at congested levels of service (LOS E or F) will increase from 1.25% in 1999 to more than 6% in 2025—a more than six-fold increase (San Joaquin Council of Governments 2002). In most cases, the potential impact of these conditions could manifest itself in deteriorating levels of service on highway segments and local streets or an extended peak-period congestion on links that are already operating at near or total breakdown conditions. In many instances, the morning peak period could extend from 2 hours to

4 hours. Likewise, as shown in Figure 3.2-3, increasing demand will lead to greater congestion, total travel time delay, and reduced reliability on the primary highway corridors in southern California.

According to the California Aviation System Plan, almost 173 million passengers enplaned and deplaned in California in 1999, a number that is expected to more than double by 2020 (California Department of Transportation 2001). Under the No Project Alternative, no additional runways or other major capacity expansion projects would be implemented by 2020. According to the Southern California Association of Governments, urbanized airports in southern California are already at 73% of total capacity and available capacity is rapidly diminishing (Southern California Association of Governments 2001). A similar trend can be expected across the state. As a result, many of the airports in the study area that are currently at or near capacity could become severely congested under the No Project Alternative. Capacity constraints are likely to result in significant future aircraft delays, particularly at California's three largest airports. SFO has "one of the worst flight delay records of major U.S. airports—only 64% of SFO flights were on time during 1998" (San Francisco International Airport 2003). According to SFO, within 10 years the three Bay Area airports will not have the sufficient capacity to meet regional air traffic demand even on a good weather day. LAX projects a demand of 19.2 million more annual passengers than their 78.7 million total passenger capacity by 2015, while San Diego International Airport expects to be at capacity prior to 2020 (San Diego Airport 2001). The projected delays at heavily used airports and forecasted highway congestion would continue to delay travel, negatively affecting the California economy and quality of life.

Given these travel trends, overall travel safety is also expected to worsen. As VMT continues to rise over the next 20 years under the No Project Alternative, the accident rate will not change appreciably, but the net number of accidents, injuries, and fatalities could increase, particularly for highway-based trips. As evidence of this trend, the National Highway Traffic Safety Administration reported that between 1998 and 2001 fatalities on California's roadways have increased by an average 4% annually (National Highway Traffic Safety Administration 2001).

Travel costs are also expected to rise because of capacity constraints. Regions could be faced with attempting to control demand through congestion pricing for both the auto and air modes. This approach could result in more congestion-priced toll roads like SR-91 in Orange and Riverside Counties, and peak-period landing fees for airports statewide. Both of these costs would be passed along to the consumer either directly in tolls or indirectly in ticketed fares.

As summarized in Table 3.2-4, the No Project Alternative could result in either a deteriorated LOS or no change compared to existing conditions.

Table 3.2-4
Existing Conditions Compared to No Project Alternative

Travel Factor	No Project Alternative (2020) Change from Existing Conditions	No Project Alternative (2020) Comment
Travel Time	Deteriorate	Increased congestion could result in further delays.
Reliability	Deteriorate	Increased congestion and no change in modal options or characteristics could result in greater unreliability.
Safety	Deteriorate	No change in modal options would maintain existing fatality and injury rates; however, increased demand could result in greater number of fatalities.
Connectivity	None	No additional intercity intermodal connections or options, or increased frequencies will be available.
Sustainable Capacity	Deteriorate	No significant mainline capacity improvements will be operational.
Passenger Cost	Deteriorate	Airfares are anticipated to increase beyond their current fare structures relative to other modal options.*

* Based on high-end forecasts from final business plan, California High Speed Rail Authority 2000.
Source: Parsons Brinckerhoff 2003.

B. NO PROJECT ALTERNATIVE VS. MODAL AND HIGH-SPEED TRAIN ALTERNATIVES

This section presents expected travel conditions for the Modal and HST Alternatives and compares relative differences between No Project and the Modal and HST Alternatives. This section is organized by the six travel factors identified earlier. Only the HST Alternative would introduce a new mode to the California intercity transportation system. This new mode would result in some major differences in expected travel conditions. Each travel factor begins with a summary of the specific methods used to define and evaluate the Modal and HST Alternatives and the characteristics of each mode followed by an evaluation of impacts for the Modal and HST Alternatives.

Travel Time
Travel time is a key travel factor that determines the attractiveness of a particular mode of travel to passengers. Travel time is also an important economic factor that directly affects productivity (travel time for workers and products to get to their destination). For the purpose of this analysis, improved travel time is a benefit to the traveler because it can improve the intercity travel experience. Travel time for this analysis was measured as the total (door-to-door) travel time for the example city pairs presented in Chapter 1. Travel times representing the duration of the air or HST trips spent in the airplane or train (line-haul times) are included in Appendix 3.2-A.

Automobile Mode Characteristics: Travel time in an automobile largely depends on three factors: distance traveled, roadway design speed (and associated speed limit), and congestion levels. The design of a roadway dictates the time that will be required to travel between two destinations. The time of day and associated congestion also plays a role in how long a trip will take. For this analysis, it is assumed that the top speed of the automobile is 70 miles per hour (mph) (113 kilometers per hour [kph]).

Automobile travel times are based on driving times between the representative city pair origins and destinations, as summarized in Table 3.2-5. The travel time for existing conditions is the same as the times used in the California High Speed Rail Authority's (Authority's) final business plan (Business Plan) and is based on weighted averages of peak and off-peak travel times

(California High Speed Rail Authority 2000). To replicate the unique congested conditions in the San Francisco and Los Angeles areas, a delay penalty of 30 minutes (min) for trips originating in or destined for the San Francisco or Los Angeles regions was added to all year 2020 projections. This assumption was also incorporated in the higher-end HST ridership and revenue forecasts from the Business Plan. The travel time savings analysis developed for the economic growth analysis of this document (Chapter 5) shows that auto travel time for the Modal Alternative is estimated to be 8.5% shorter than for the No Project Alternative because of the reduction in congestion due to the increase in capacity on the highway system. In the same analysis, the auto travel times for the HST Alternative are estimated to be 4.1% shorter than the Modal Alternative because of the diversion of highway trips to the HST system (California High Speed Rail Authority 2000a).

Table 3.2-5
Total Door-to-Door Automobile Travel Times (Hours:Minutes)

		2020 (Alternatives) Automobile Total Door-to-Door Travel Times[b]		
City Pairs	**Existing Conditions (1999)[a]**	**No Project**	**Modal**	**HST**
Los Angeles downtown to San Francisco downtown	6:57	7:57	7:16	7:36
Fresno downtown to Los Angeles downtown	4:00	4:30	4:06	4:18
Los Angeles downtown to San Diego downtown	2:19	2:49	2:35	2:41
Burbank (airport) to San Jose downtown	5:50	6:50	6:15	6:32
Sacramento downtown to San Jose downtown	2:10	2:40	2:26	2:33

[a] California High Speed Rail Authority's final business plan, 2000, and Independent Ridership and Charles River Associates, Passenger Revenue Projections for High Speed Rail Alternatives in California, 2000.

[b] Sum of existing conditions plus representative delay penalty of 30 min for origin and destinations at San Francisco or Los Angeles, which is consistent with the high-end revenue and ridership forecasts for the Business Plan. Under the low-end revenue and ridership analysis the travel time under No Project would be the same as existing conditions.

Source: Parsons Brinckerhoff 2003.

Air Mode Characteristics: Air travel is the fastest line-haul mode at 530 mph (853 kph) maximum cruising speed. However, a significant portion of a passenger's trip is spent accessing the airport, passing through one or more security checkpoints, boarding and alighting the aircraft, and egressing the airport. The components of a door-to-door air trip include the components listed below. (See Appendix 3.2-B for more detailed explanation.)

- Access time: time spent driving to the airport.
- Terminal time: time spent getting through the airport terminal.
- Line-haul time: time spent on the aircraft.
- Arrival time: time spent getting to the final destination.

It is assumed that all air trips would require travel on the regional highway system with the exception of San Francisco, where some passengers could use the newly opened BART to SFO rail link. Also, passengers in the Los Angeles area could use a Metrolink connection to Burbank.

Total air travel times are summarized in Table 3.2-6. As shown, No Project travel times would increase between 15 and 30 minutes compared to existing conditions, depending on city pairs.[1] These changes are due to increases in line-haul travel time resulting from insufficient capacity at airports under No Project. It is estimated that air travel times would change under the Modal and HST Alternatives compared to No Project because the additional infrastructure under the Modal Alternative and the diversion of trips to HST would reduce airside congestion levels, while all other factors (arrival, terminal, and departure times) would remain constant (California High Speed Rail Authority 2003). Although there would be an improvement of intercity highway travel times, this improvement is not meaningful for access trips to and from the airports.

Table 3.2-6
Total Door-to-Door Air Travel Time (Hours:Minutes)

City Pairs	Airports	Existing Conditions (1999)	2020 Alternatives Air Mode Total Door-to-Door Travel Times		
			No Project Alternative[a]	Modal[b]	HST[c]
Los Angeles downtown to San Francisco downtown	LAX, LGB, BUR, SNA, ONT, SFO, OAK, SJC	3:02	3:32	3:27	3:26
Fresno downtown to Los Angeles downtown	FAT, SNA, ONT, LAX, LGB, BUR	2:47	3:02	3:01	3:00
Los Angeles downtown to San Diego downtown	LAX, LGB, BUR, SNA, ONT, SAN	2:30	3:00	2:45	2:46
Burbank (Airport) to San Jose downtown	BUR and SJC	2:44	3:14	3:09	3:08
Sacramento downtown to San Jose downtown	SMF and SJC	No Service	No Service	No Service	No Service

N/A = Not applicable.

[a] 15-min penalty for San Francisco, Los Angeles, and San Diego area airports based on high-end ridership and revenue forecasts from the Business Plan. Under the low-end forecasts, travel time in 2020 would be the same as under existing conditions.

[b] Total travel time reduced based on increase in capacity at airports.

[c] Total travel time reduced because of reduction in demand at airports from trips shifting from air to HST.

Source: Parsons Brinckerhoff 2003.

High-Speed Train Mode Characteristics: With a maximum operating speed of 220 mph (354 kph), the HST is slower in line-haul speed than an airplane but considerably faster than an automobile. However, for most intercity trips within California, the quick arrival, terminal, and departure times make the overall HST travel time competitive with that of air travel. The HST would also connect closer city pairs, those less than 150 mi (241 km) apart, and for those trips would compete strongly with the automobile. For example, HST travel between Los Angeles and Bakersfield or Sacramento and Modesto would likely be faster than automobile travel.

In Europe and the United States, rail travel time improvements have shifted travel demand from air to rail travel. Within a decade of its inauguration, France's Train à Grande Vitesse (TGV) Sud-Est succeeded in capturing more than 90% of the travel market between Paris and Lyon (Meunier 2002). Amtrak's Acela and Metroliner trains have 50% of the total air-rail market, which is split between New York and Washington. In Germany, recent passenger rail improvements between Frankfurt and Cologne were undertaken with the purpose of shifting air

[1] This assumption is consistent with the high-end revenue and ridership assumptions for the Business Plan.

trips from congested airports where capacity was constrained and could not be expanded to high-speed rail that could more quickly serve the same markets. This same principle could apply to the major airports in the study area, including San Francisco and Los Angeles. The air operation time-slots released by substituting HST for local air service at these two airports could provide more opportunities for international and interstate flights.

HST would also provide direct connections to several airports. This connectivity, combined with the line-haul speed of the HST, could result in faster total travel times for air travelers who use air travel and the HST to reach their final destination. For example, passengers arriving at San Francisco could transfer to the HST and travel to Merced, and this connection could be competitive with or possibly faster than connecting to another flight, driving, or taking a bus or shuttle.

The train in this instance may be quicker for two reasons. First, trains may be boarded swiftly, often in less than 2 minutes because of the number of doors and ability to accommodate extra passengers. In contrast, boarding an airplane must be controlled for security and typically takes place through one door (or at most two doors), a process that can take up to half an hour. Second, current airline boarding practice requires passengers to be present at the gate at least 20 minutes before the scheduled departure time.

Another key difference between HST and air travel is the percentage of total travel time spent during the line haul. On a train, this proportion of time is quite high, and can be used for work, pleasure, or relaxation. For example, passengers traveling by HST between any of the below city pairs would be able to use their laptop computers or any number of personal audio, video, or game devices for approximately 70% of the total travel time, while passengers traveling by air would be able to use these devices for just 30% of their trip.[2]

Total travel times are summarized in Table 3.2-7. Since no HST exists or would exist under the No Project or Modal Alternatives, only the travel times for the HST Alternative are shown. While these travel times are from downtown to downtown where HST has a distinct advantage over air travel because of terminal locations, the potential for many online stations could make the HST competitive for many other trips. Like air travel, the HST has the following door-to-door trip components. (See Appendix 3.2-B for more detailed explanation.)

- Access time: time spent driving to the train station.
- Terminal time: time spent getting through the train station.
- Line-haul time: time spent on the train.
- Arrival time: time spent getting to the final destination.

[2] Although the line-haul time of the flight is about 33% of the total trip, due to restrictions on use of electronics during take off and landing, the productive time is reduced by another 10%.

Table 3.2-7
Total Door-to-Door High-Speed Train Mode Travel Times (Hours:Minutes)

City Pairs	2020 HST Total Door-to-Door Travel Times
Los Angeles downtown to San Francisco downtown	3:20
Fresno downtown to Los Angeles downtown	2:23
Los Angeles downtown to San Diego downtown	2:16
Burbank (airport) to San Jose downtown	2:52
Sacramento downtown to San Jose downtown	1:53
Source: California High Speed Rail Authority 2000.	

Existing conventional rail services are typically not competitive with other modes. For example, while the HST line-haul time (a component of total trip time) between downtown San Francisco and Los Angeles would be just under 2.5 hrs, the only existing direct rail service between the Bay Area (Oakland) and Los Angeles (Coast Starlight service) currently has a line-haul time of more than 12 hrs and operates one train daily in each direction. The San Joaquin service between Oakland and Los Angeles currently takes about 8 hrs and 40 min but requires transferring to a bus for the Bakersfield to Los Angeles segment of the trip. The HST line-haul time between downtown Los Angeles and downtown San Diego would be about 1 hr and 13 min as compared with current Surfliner line-haul time of 2 hrs and 45 min. Caltrans and Amtrak plan to reduce travel times by up to 30% on key intercity routes such as the Pacific Surfliner and Capitol Corridor services over the next 20 years; however the projects required to reach these goals are not yet funded.

Alternatives Comparison for Travel Time
No Project Alternative: There are no travel-time benefits associated with the No Project Alternative because there are no significant improvements to capacity or modal options. The No Project Alternative would likely result in longer travel times in all cases as compared to existing conditions, and these increases would range between 15 and 60 minutes for the representative city pairs.

Modal Alternative: The Modal Alternative could achieve up to a 16-min reduction in travel time for the representative city pairs compared to the No Project Alternative. The greatest savings would be achieved in the most congested corridors of Sacramento to San Francisco. These benefits would occur primarily due the additional highway capacity in the Bay Area and southern California regions with the Modal Alternative. It is estimated that with the additional capacity proposed for airports there would be some travel time benefits over the No Project Alternative.

High-Speed Train Alternative: The greatest time savings would be achieved using express service between Fresno and Los Angeles and between Los Angeles and San Diego. Because of its faster line-haul speed, HST would compete with the automobile for shorter distance intercity trips. Because of its shorter terminal processing times, HST would also compete with the airplane for longer distance intercity trips. In the Central Valley, HST would provide shorter travel times than both the highway and air modes for travelers headed to locations near HST stations.

Reliability
In its simplest form, *reliability* can be defined as variation in travel time, hour-to-hour and day-to-day for the same trip. Reliability is important for almost any travel need and on any travel mode. Business travelers want to be able to predict how long it will take them to arrive at a meeting,

either across town or across the state. Express shippers need to know where packages are at all times and when they will be available for delivery. Vacationers who want to spend as little of their time off as possible traveling to and from their destinations often find themselves making their trips during the most congested days of the year. Reliable travel means fewer late arrivals, improved efficiency, saved time, and reduced frustration.

Travel on most transportation modes is consistent and repetitive, yet at the same time highly variable and unpredictable. This apparent contradiction accrues because travel is consistent and repetitive since peak usage periods occur regularly and can be predicted. The relative size and timing of rush hour is well known in most communities. Simultaneously, travel is variable and unpredictable because on any given day unusual circumstances such as a rainstorm or an auto accident can cause serious delays at any time.

The traveling public's experience with variations in travel reliability affects their decisions of how and when to travel, so that they have a reasonable expectation that they will arrive at their destination at a particular time. For example, if a highway is known to have highly variable traffic conditions, a traveler using that route to catch a flight routinely leaves extra time reach the airport.

Travel time reliability is the direct result of the variable and often unpredictable events that can occur on different travel modes and at any time of day. The traditional way of measuring and reporting travel times experienced by highway users is to consider only average or typical conditions. However, the travel times experienced by users are seldom constant, even for travel on the same facility in the same peak or off-peak time period. Reliability is influenced by several underlying factors that vary over time and that influence the environment within which transportation operates. These factors are listed below.

<u>Incidents</u>: *Incidents* are events that disrupt normal travel flow, such as obstructions in the travel lanes of highways. Events such as vehicular crashes, mechanical breakdowns, and debris in travel lanes are the most common form of incidents for any mode. On highways, events that occur on the shoulder or roadside can also influence traffic flow by distracting drivers, leading to changes in driver behavior and ultimately to the quality of traffic flow.

<u>Inclement Weather</u>: *Inclement weather* and related environmental conditions (rain, fog, snow, ice, sun glare, etc.) can lead to changes in operator behavior, vehicle performance, and operational control requirements that affect traffic flow. Motorists respond to inclement weather by reducing their speeds and increasing their headways. Airport and civil aviation authorities respond by grounding flights or delaying takeoffs and landings. In cases of severe weather, authorities respond by closing roadways and creating vehicle caravans.

<u>Construction</u>: Construction can often reduce the number, width, or availability of travel lanes, rail tracks, and runways. Nearby construction activities can also reduce reliability if operating rules or conditions are changed (e.g., slow orders on rail tracks). Delays caused by work zones have been cited by highway travelers as one of the most frustrating conditions they encounter on trips.

<u>Volume Variation</u>: *Volume variation* is day-to-day variability in demand that leads to some days with higher travel volumes than others. Different demand volumes superimposed on a system with fixed capacity results in variable, less reliable travel times.

<u>Special Events</u>: Special events such as concerts, fairs, and sports events cause localized congestion and disruption in the vicinity of the event that is radically different from typical travel patterns in the area.

Traffic Control Devices and Procedures: These can lead to intermittent disruption of travel flow through means such as air traffic control, railroad signals and switches, railroad grade crossings, drawbridges, and poorly timed signals.

Base Capacity: *Base capacity* refers to the physical capacity of a transportation system, such as the number the highway lanes or runways. The interaction of base capacity with the other influences on reliability has an effect on transportation system performance. This is due to the nonlinear relationship between volume and capacity on any mode. When congested conditions are approached, small changes in volume lead to diminished throughput of the transportation system and consequent large changes in delay. Further, facilities with greater base capacity are less vulnerable to disruptions; for example, an incident that blocks a single lane has a greater impact on a highway with two travel lanes than a highway with three travel lanes.

Vehicle Availability and Routing: These can directly affect a traveler's ability to make an on-time trip, particularly on a common carrier such as airplane and train, or by rental car. End-to-end routing, hubbing,[3] and other strategies to maximize vehicle operation time can affect reliability when a vehicle that is needed in one location first has to complete a trip from a different location. Short layovers or "pads" that are scheduled between trips for a given vehicle also affect vehicle availability.

The extent to which these eight factors affect each of the major intercity travel modes, and by extension the Modal Alternative and HST Alternative, is analyzed and compared on a qualitative basis by describing and ranking the extent to which each travel mode is potentially susceptible to each of the eight factors. It is presented in Table 3.2-8 and further detailed below. Because the alternatives are composed of combinations of modal elements (including different modes for trip segments like station or terminal access), modal rankings have been combined, providing a qualitative understanding of the reliability of each alternative.

Table 3.2-8
Modal Reliability

	Relative Susceptibility to Reliability Factors*		
Factor	**Air**	**Automobile**	**High-Speed Train**
Incidents	**Low** Air travel has very few major incidents, and is generally not influenced by incidents on other modes.	**High** Automobile travel can be influenced by minor and major incidents at any location along the roadway and is frequently affected by incidents outside of the right-of-way.	**Low** HST has very few major incidents and is generally not influenced by incidents on other modes since the number of grade crossings is minimal or non-existent.
Weather	**High** A variety of weather conditions anywhere in the country can affect air travel.	**High** A variety of weather conditions can degrade operator ability, make roadways impassible, or damage roadways.	**Low** Trains can operate under virtually any conditions. Guideway is constructed to minimize weather impact.

[3] Hubbing is a reference to the "hub and spoke" operations practice where airlines coordinate a large number of their flights to arrive at a major terminal at the same time to allow passengers to transfer from one plane to the next to complete their trip to their final destination.

Factor	Relative Susceptibility to Reliability Factors* Air	Automobile	High-Speed Train
Construction	**Low** Most activities scheduled for periods of low airport usage. High-quality construction minimizes routine maintenance needs.	**Moderate** Construction activities (major and minor) are common, but generally occur during warm weather months. Lane closures are often of long-term duration.	**Low** Most activities are scheduled for hours when system is closed. High-quality construction minimizes routine maintenance needs.
Special events	**Low** Special events (e.g., air space closure) are generally rare but can lead to rerouting or airport closure when they do occur.	**Moderate** Special events are common and can create volume fluctuations or short-term lane closures.	**Low** Most special events can be easily accommodated on HST without effect on travel time. Guideway closures are uncommon for this factor.
Traffic control devices or procedures	**Moderate** Reliability strongly influenced by air traffic control rules and capabilities.	**Moderate** Auto travel influenced by traffic signals, railroad crossings, and other devices. Influence depends on level to which devices are optimized.	**Low** HST operates in exclusive, grade-separated right-of-way, minimizing external influences. Double-tracked guideway minimizes switching needs. HST control systems are redundant and highly automated, allowing for a high level of precision in dispatching and control.
Inadequate base capacity	**Moderate** Capacity can be strong influence due to complex procedures for gate usage, taxiing, and takeoffs/ landings. This factor has strong interaction with weather at certain airports.	**High** This is one of the strongest influences on highway reliability, particularly for facilities with three or fewer lanes per direction. Travel time degrades quickly as capacity is approached.	**Low** HST system generally has large capacity reserve. Operations are not allowed to exceed design capacity. Exclusive guideway maintains high level of base capacity at all times.
Volume variation	**Moderate–High** Air travel demand and number of scheduled flights fluctuates broadly from day to day. Aircraft loading and unloading times directly affected by passenger volumes.	**High** Peak-period travel in medium to large urban areas highly influenced by day-to-day or seasonal volume variations. Strong interaction with inadequate base capacity.	**Low** Day-to-day variation in train volumes tends to be low. Passenger volume variation generally does not influence travel times.
Vehicle availability or routing	**High** Airplanes are used multiple times in a given day, and availability can be affected by factors anywhere in the world and with any type of routing system (point-to-point or hub-and-spoke). High capital cost discourages airlines from keeping large reserve fleet.	**Low** Private automobiles are ubiquitous and are widely available for rental in emergency situations. The road and highway network provides alternative routes for most trips.	**Moderate** HST vehicles complete multiple end-to-end trips in a day, potentially affecting availability at specific times and locations; simple routing schemes generally followed.

* High indicates that the factor can exert a strong negative influence on travel time reliability for the mode. Conversely, low indicates that the factor generally does not play a role in influencing travel time reliability for the mode.

Source: Cambridge Systematics, Inc. 2003.

Automobile Mode Characteristics: On a day-by-day basis, automobiles tend to be the least reliable of the three modes. Highway travel is highly or moderately susceptible to seven of the eight factors described above. It is only when considering the influence of vehicle availability and routing that automobiles potentially would have a lower susceptibility than other modes.

Recent research provides further evidence on the unreliability of highway travel (Texas Transportation Institute and Cambridge Systematics, Inc. 2003). This research, which used actual travel time data covering 579 mi (932 km) of freeways in the Los Angeles area, shows that reliability problems exist on highways at all times of the day, all days of the week, and all weeks of the year. This research expressed unreliability in terms of a *buffer index,* the amount of extra time motorists would need to budget to be certain of arriving on time at their destination 95% of the time. Results showed that a motorist in Los Angeles would need to allow an additional 45 min for a typical 1-hr highway trip—fully 75% of normal driving time. Even in midday periods, a traveler would need to budget an additional 30 min for the same 1-hr trip, or 50% of the normal time. It is important to note that a buffer does not represent certainty, and on any given day this buffer may or may not be needed.

Air Mode Characteristics: Despite its high average speed, air travel often suffers from reliability problems due to a number of factors. The data in Table 3.2-8 suggest that air travel is moderately or highly susceptible to weather, vehicle availability, volume variation, inadequate base capacity, and traffic control procedures. Air travel is more susceptible than the other two modes to reliability problems arising from weather and vehicle availability. Bad weather and a shortage of aircraft in other states can impact service in California. Air travel reliability is generally not, however, influenced by incidents, construction, and special events.

Airline on-time statistics compiled by the Federal Aviation Administration show air travel reliability problems are widespread in California. Airline on-time statistics are available through the Bureau of Transportation Statistics Web site (http://www.bts.gov/ntda/oai). These statistics were reviewed to compare actual versus scheduled flight times for flights departing from Sacramento (SMF), SFO, LAX, and San Diego (SAN) in June 2002.[4] The statistics were analyzed to determine the median scheduled flight time and the 95th percentile actual flight time for flights departing from these four airports.[5] These times and the resulting buffer are shown in Table 3.2-9.[6]

The data in Table 3.2-9 indicate that air travel is generally more reliable than highway travel, as suggested by the smaller buffers (10 to 15% for air travel versus 50 to 75% for highway travel). Nonetheless, the data also show that air travelers at these four airports still need to budget an additional 9 to 18 min of in-vehicle travel time to account for unforeseen reliability problems that often arise with air travel.

4 Statistics were analyzed for all flights operated by Alaska, America West, American, American Eagle, Delta, Southwest, United, and United Express. These eight airlines account for more than 95% of domestic departures at these four airports. More than 29,000 individual flights were included in the sample.

5 The 95th percentile was chosen to maintain consistency with the research results reported for the highway mode.

6 As with the highway mode, the buffer indicates the additional time needed above the average (median) time air travelers would need to budget to arrive on time for their flight with 95% certainty. For air travel, the buffer is expressed as a percentage of the median flight time.

Table 3.2-9
Reliability Statistics for Air Travel in California

Airport	Delay (95th Percentile Travel Time)	Scheduled Flight Time (Median)	Buffer (Delay/Scheduled Flight Time)
Sacramento (SMF)	9 min.	85 min.	10.6%
San Diego (SAN)	12 min.	90 min.	13.3%
San Francisco (SFO)	18 min.	118 min.	15.3%
Los Angeles (LAX)	12 min.	110 min.	10.9%
Source: Bureau of Transportation Statistics, June 2002.			

<u>High-Speed Train Mode Characteristics</u>: HST has been shown to have a low susceptibility to nearly all of the major factors that affect reliability. It is only on the issue of vehicle availability that HST, like all common carrier modes, has a higher level of susceptibility than highways. Also, HST has the same or lower level of susceptibility on all eight factors compared with air travel or even conventional rail.

Statistics from HST operations in Europe and Asia further confirm the high level of reliability that is inherent with HST. In France, more than 98% of TGV train runs have been completed within 1 min of schedule. In Spain during 2002, 99.8% of AVE runs were completed within 5 min of schedule. In Japan, the JR Central Shinkansen line averaged a 16-second delay per train in 2002. Using the buffer concept that was described for highways and air, these data suggest that HST travelers would likely need to have a schedule buffer less than 1 min (less than 1% of scheduled travel time) to account for unforeseen delay and reliability. This in-vehicle travel time buffer is extremely small compared to all other modes.

HST systems have proven worldwide to be far more reliable than conventional U.S. intercity rail services. Several factors account for this reliability.

- Intercity rail service involves mixed operations between conventional intercity passenger services and heavy freight traffic, whereas the HST service would not share tracks with heavy freight services.
- Depending on location and number of operations, the quality of train signal/control/dispatch systems for freight rail systems vary, whereas the HST services would use state-of-the-art automated control systems.
- Most conventional intercity passenger rail routes operate on freight railroads that are dispatched by the host freight railroad. Therefore, dispatching decisions may be based first on the needs of the host railroad, and then on the needs of the passenger train. For example, if a freight train is too long to go into a siding, the dispatcher will have to put the passenger train in the siding to wait until the longer freight train passes. This is just one type of delay for passenger trains using freight railroads.
- Grade crossings are inherently dangerous, providing the opportunity for vehicle and pedestrian collisions and delay due to malfunction of grade-crossing protection equipment. The HST service would be completely double-tracked, fenced, and grade-separated.

Although detailed statistics were not available, reports on rail operations in California suggest that conventional rail reliability is low (California Department of Transportation 2002). While Amtrak strives to complete a minimum of 90% of its train runs on time, the most recent data shows that the Capitol Corridor is on time about 84% of the time, while intercity service within the LOSSAN corridor is on time about 78% of the time. Monthly statistics for the Capitol Corridor show that the 90% on-time goal has only been reached in 2 of the past 24 months.

Alternatives Comparison for Reliability
A qualitative comparison of the alternatives was conducted by considering the relative reliability of the modes that are present in each alternative, the relative modal usage in each alternative, and any major changes such as highway lane additions or modal diversion that are present in an alternative. As described more fully below, the HST Alternative is projected to have the highest reliability, while the No Project Alternative is projected to have the lowest reliability.

No Project Alternative: Reliability under the No Project Alternative is likely to be lower than under the other alternatives for the following reasons.

- The No Project Alternative depends heavily on the automobile, which has been shown to have the worst reliability of the three modes.
- Existing congestion and reliability problems continue, because the No Project Alternative provides no new highway and airport base capacity.
- Greater highway and aviation congestion and more reliability problems accrue, because the No Project Alternative absorbs an increasing demand for travel with little increase in base capacity.

Modal Alternative: The Modal Alternative is likely to have better reliability than the No Project Alternative, but poorer reliability than the HST Alternative for the following reasons.

- The Modal Alternative depends heavily on the automobile, which has been shown to have the worst reliability of the three modes.
- Lower congestion and less susceptibility to reliability problems would result because the Modal Alternative could provide more base capacity to carry the expected increase in travel demand on highways and at airports than the No Project Alternative.

The Modal Alternative is likely to result in lower highway and air congestion levels than the HST Alternative since there is a measurable increase in capacity for both modes. Since the capacity increases between the No Project Alternative and the Modal Alternative but the number of intercity trips does not, less delay is accredited under the Modal Alternative to capacity constraints on both roadways and at airports. Nonetheless, Chapter 1 and Section 3.1 of this Program EIR/EIS have shown that the Modal Alternative would still experience near-capacity conditions on many highways and airports, increasing the likelihood of reliability problems. These problems would be compounded by the lack of a reliable alternative travel mode, such as the HST.

High-Speed Train Alternative: The HST Alternative is likely to provide the greatest degree of travel reliability for the following reasons.

- HST would divert significant levels of intercity demand from less reliable modes, particularly highways.
- HST provides a completely separate transportation system that would have less susceptibility to many factors influencing reliability.
- Highway and air travel reliability would improve because HST reduces travel demand on highways and air.

The various HST alignment options are not likely to exhibit appreciable differences in system reliability since system capacity and demand would be roughly equivalent. Major design differences (e.g., extent of tunneling) would not make a meaningful difference in reliability, and differences in base travel times on HST would not influence reliability.

Sensitivity to Travel Demand Forecasts: As with travel time, reliability is also influenced by the level of travel demand. Other things being equal, reliability is expected to be better on facilities that have lower travel demand (or experience lower V/C ratios) due to the non-linear relationship between volume and capacity, as mentioned above. Therefore, lower levels of highway or air travel demand, such as those suggested by the base Business Plan forecasts, would be expected to improve reliability for the highway and air modes for the Modal and HST Alternatives. The reliability improvement would likely be greatest for the No Project Alternative since its base capacity is most constrained and would experience the largest relative improvement in V/C ratios and delay. For the same reasons, the Modal Alternative would likely experience the second-largest reliability improvement, and the HST Alternative would experience the smallest improvement. Nonetheless, given the large reliability advantage enjoyed by the HST mode, the HST Alternative would still be expected to provide the greatest degree of travel reliability across the range of travel demand scenarios suggested in the Business Plan.

Safety

In transportation, three basic characteristics interact to influence the safety of a mode.

- Operator: His or her training, regulation, and experience.
- Vehicle: Its condition, regulation, control systems, and crashworthiness.
- Environment: Weather, guideway type, guideway condition, and terrain.

Each of these characteristics plays a role in the overall safety of the modes, which for this analysis is quantified as the probability of passenger fatality. Injuries are more difficult to compare between modes because they are categorized differently by mode and different injury ratings are used. For instance, automobile injuries are generally related to automobile crashes, while for air, bus, and rail they can include injuries that occur as part of a crash, while boarding/alighting, or in the terminal. The severity of these injuries can vary from scrapes and bruises to life-threatening ones. For the purposes of this analysis, injuries by mode will be discussed but are not measured as a key indicator of safety. This analysis also only considers injuries and fatalities of passengers and does not include employees or other staff.

To compare the relative impact of safety between alternatives, fatalities are measured by rate of fatality per 100 million passenger miles traveled. For this analysis the high-end forecasts were assumed because this approach will present the worst case for potential fatalities for all modes and alternatives. The safest mode is the one that has the lowest number of fatalities per 100 million passenger miles traveled (PMT).

Automobile Mode Characteristics: The automobile is unquestionably the most used and the most dangerous mode of transportation being considered in this Program EIR/EIS. The National Highway Traffic Safety Administration estimates that the national motor vehicle fatality rate is 0.80 fatalities per 100 million passenger miles traveled. Nationally in 2000, there were about 6.4 million reported motor vehicle crashes that resulted in 42,000 fatalities and 3.2 million injuries. About 4.2 million crashes involved property damage only (National Highway Traffic Safety Administration 2001). The National Highway Traffic Safety Administration estimates that deaths and injuries resulting from motor vehicle crashes are the leading cause of death for persons between the ages of 4 and 33, while traffic-related fatalities account for more than 90% of all transportation-related fatalities. According to the California Highway Patrol, in 2000 there were 3,331 fatal crashes in California alone (California Highway Patrol 2000). The risk to an individual depends most strongly on the time spent behind the wheel or in the passenger's seat. The longer the journey or the more frequently the journey is made, the greater the risk of a crash. Some of the factors that influence auto and highway safety are listed below.

- Operator.
  - Drivers vary in age, experience, ability, and many other factors.
  - Non-professional drivers typically operate automobiles.
  - Limited regulatory requirements govern who can operate an automobile and the type of training that is needed, and these requirements vary between states.
- Vehicle.
  - Privately owned vehicles are mechanically not as reliable as the public transportation modes.
  - Maintenance and inspections are not regulated, and are performed by mechanics of varying skill levels.
  - Crashworthiness and roadworthiness varies depending on make and model.
  - Minimum requirements rather than optimum standards dictate safe operating conditions.
- Environment.
  - Highways provide no latitudinal or longitudinal control to individual automobiles.
  - Fixed objects (e.g., trees, light poles, sign posts) are frequently placed within the highway right-of-way.
  - Weather and lighting conditions (wind, rain, fog, snow, ice, darkness, and sun glare) can adversely impact vehicle and driver performance.
  - Traffic control systems that regulate the speed and safe operation of an automobile are limited in influence.
  - Roadway conditions and designs are varied and can include systems based on different design speeds, vehicles, and operating conditions.
  - Drivers are subject to a multitude of potential distractions and interferences.

Air Mode Characteristics: Air travel is a safe mode of travel and in recent years has become even safer with the introduction of improved aircraft and state-of-the-art air traffic control systems. According to the U.S. Department of Transportation, the likelihood of fatality due to commercial air travel is relatively small (0.02 fatalities per 100 million PMT). According to the University Of Michigan Transportation Research Institute, flying a typical nonstop flight is 65 times safer than driving the same distance. Takeoff and landing presents the greatest safety risk during a flight; between 1991 and 2000, 95% of all airline fatalities occurred either during takeoff or landing, and just 5% of fatalities occurred at cruising altitudes (Sivak and Flannagan 2002). Consequently, the risks of flying depend mostly on the number of segments flown and not on the distance flown. Injuries associated with air travel can occur during the process of boarding and alighting, and during flight. Most are relatively minor and include scrapes, bruises, broken bones, and a few serious falls. Some of the factors that influence air travel safety are listed below.

- Operator.
  - Commercial aircraft can only be operated by professional pilots, who are rigorously trained and must update their proficiency regularly.
  - Other airline personnel such as flight attendants are trained to provide immediate assistance in emergency situations.
  - Pilots are subject to drug tests and are regulated by the Federal Aviation Administration.
  - Automation of fight operations is well developed and commonly installed.
- Vehicle.
  - Aircraft are regularly maintained to high standards and the Federal Aviation Administration regularly inspects these maintenance records.
  - Aircraft themselves are constructed of high-grade metals and, provided they are maintained regularly, can be in active service for decades.
  - All aircraft occupants are required to wear seatbelts during takeoffs and landings, the two procedures that present the greatest safety risk.
  - Air traffic control systems in the United States are standardized and are some of the safest, most reliable systems in the world for controlling commercial aircraft and warning them of potential dangers.
- Environment.
  - One of air travel's greatest weaknesses is its vulnerability to weather. Although most commercial aircraft can fly above or below most storm systems, they often have no choice during takeoffs and landings but to fly through thunderstorms, snow, ice, and fog. Particularly severe weather conditions can ground all aircraft and prevent those in flight from landing.
  - Unexpected turbulence during flight can injure passengers. For this reason, passengers are often required to wear seat restraints and are discouraged from walking or standing during flight.
  - Aircraft have no guideway to provide latitudinal or longitudinal control, and therefore run the risk of striking fixed or other flying objects while on the ground or during flight.

High-Speed Train Mode Characteristics: Based on statistics from Europe and Japan, HST is the safest mode of travel.[7] Since 1988, there have been 85 injuries and 14 fatalities[8] reported on all dedicated HST systems in Europe. In Japan's 34 years of HST operations, no passenger injuries or fatalities have been reported. For the purposes of this analysis and for comparison purposes only, it is assumed that the fatality rate for HST is less than air travel but greater than 0.0, or 0.001 per 100 million PMT. Similar to air travel, the likelihood of injury is associated with boarding and alighting, and during operation, with injuries ranging from minor to severe. The distinguishing reasons for the safety of HST travel relative to air and highway travel are summarized below. The HST mode would be much safer than conventional intercity rail services in California, which operate on freight railroads that have a mix of rail traffic and grade crossings.

[7] There are no statistics for HST safety in the United States.

[8] The worst accident on a dedicated high-speed right-of-way was a derailment in Piacenza, Italy in 1997, which resulted in eight fatalities.

- Operator.
  - HST operators would be rigorously trained and tested and are required to update their qualifications regularly.
  - HST operators would be required to submit to drug tests and are subject to regulation by the FRA and operating railroads.
  - The train would be completely automated and the train operator would be a failsafe redundant system component that could act in the unlikely case that a system malfunction or other problem occurs.
- Vehicle.
  - The FRA passenger equipment safety standards (49 C.F.R. Part 238) dictate the buff strength or amount of force a train can withstand in a collision, for all passenger equipment. The buff strength is adjusted to the operating and rail traffic conditions and is designed to minimize injuries of fatalities due to rail crashes.
  - The trains would be completely automated, allowing for centralized command and control of the train system, effectively eliminating the chance of operator error. Much like the BART system in the San Francisco Bay Area, a centralized system would control the operation of the train while the operator would be the physical eyes and ears of the train ensuring passenger safety.
  - Like airplanes, trains and the infrastructure they operate on (tracks, control systems, and electrification systems) would be maintained on a regular schedule. Maintenance records are subject to inspection by the FRA.
  - Like aircraft, passenger train equipment is built for a long service life. If maintained properly, a modern train car can have a useful life of at least 30 years.
  - HST traffic control and communications systems are state-of-the-art, regulated and managed during all hours of operation. These systems control the train's speed, schedule, routing, and headway (following distance behind another train). These systems combined with the operator have integral redundancy and ensure safety.
- Environment.
  - The HST system would be fully fenced and grade-separated (including grade crossings), virtually eliminating pedestrian and motor vehicle conflicts.
  - The HST system would be closed to all other rail traffic, greatly reducing the possibility of collision with other trains. An exception is the Caltrain corridor between Gilroy and San Francisco, where the HST would travel at reduced speeds and share the track with express commuter passenger trains.
  - Inclement weather has only a minimal impact on HST operations. Because it is nearly impossible to read line side signals flashing by at 200 mph (322 kph), HSTs use a cab signaling system that transmits commands directly to the driver. This technology makes high-speed operation possible in darkness, rain, and fog. In Japan, even moderate snowfall does not slow the Shinkansen because of special ice-melting equipment built into the rail bed.
  - Unlike aircraft, HST systems are not subject to turbulence. Passengers may sit without seat restraints and may stand and walk comfortably even at maximum speeds and around curves.
  - Although HST systems do operate in highly seismic areas such as Japan, no injuries or fatalities have ever occurred as a result of a seismic event. Failsafe technology would

stop the trains when an earthquake is detected, and at-grade construction in fault zones would further improve safety.

- The HST system, like other public intercity modes, is inspected on a regular schedule as required in federal regulations. This regular inspection of both rolling stock and track would ensure the safety of the HST.

The safety characteristics of each mode are summarized in Table 3.2-10. This table shows that for all three safety characteristics, the HST mode has the best safety performance. While air and HST are similar in regard to operator and vehicle characteristics, HST performs better with regard to the environment because the HST is capable of operating safely and comfortably in a variety of climatic conditions compared to aircraft, without the need for passenger restraints. The automobile mode fares poorest in terms of safety.

Table 3.2-10
Safety Performance by Mode

	Safety Performance Characteristics		
Mode	**Operator** Training Regulation Experience	**Vehicle** Condition Regulation Control systems Crashworthiness	**Environment** Weather Guideway condition Terrain
Automobile	Poor	Good	Poor
Air	Excellent	Excellent	Poor
HST	Excellent	Excellent	Excellent

Alternatives Comparison for Safety

The safety performance for each alternative is shown in Table 3.2-11. The HST Alternative has the best overall safety performance primarily because it diverts 34 million annual passengers from the least safe automobile mode to HST[9], the safest mode. This demand shift combined with the rigorous requirements of HST operators, regular vehicle inspection, maintenance, control systems, crashworthiness, and ability to operate in virtually all weather conditions, make the HST Alternative superior to No Project and Modal Alternatives.

Table 3.2-11
Safety Performance by Alternatives

	Safety Performance Characteristics		
Alternative	**Operator** Training Regulation Experience	**Vehicle** Condition Regulation Control systems Crashworthiness	**Environment** Weather Guideway condition Terrain
No Project	Good	Good	Poor
Modal	Good	Good	Poor
HST	Excellent	Excellent	Excellent

[9] This number is based on the high-end ridership forecast for the HST based on the Business Plan. If the HST ridership were less (42 million instead of 68 million, including 10 million long-distance commuters for both the low and high forecasts), then fewer trips would be diverted from auto, effectively increasing the overall number of potential fatalities per year.

No Project Alternative: While the rate of injury or fatality is not expected to increase under the No Project Alternative, the increase in highway travel would be expected to cause the number of injuries and fatalities to increase as compared to existing conditions.

Modal Alternative: No significant safety benefits are associated with the Modal Alternative compared to the No Project Alternative, with about the same number of highway-related fatalities projected to occur under either scenario. However, because the Modal Alternative would provide some excess capacity not used by intercity highway or air trips, the additional capacity would likely be absorbed by commuting or other local trips. These induced trips could add to the amount of travel (PMT) on certain segments and could increase the number of fatalities. Furthermore, while the Modal Alternative also includes an improvement to air travel capacity and may ultimately increase the demand for air travel, these trips are more likely to use local and regional roadway systems to access the airports than under the HST Alternative, and this outcome could also pose a potential safety risk.

High-Speed Train Alternative: The HST Alternative would produce the greatest safety benefit compared to the No Project and Modal Alternatives. HST would divert about 34 million annual intercity highway trips from the Modal or No Project Alternatives, resulting in fewer injuries and fatalities annually.

Connectivity

Connectivity in the study area can be measured qualitatively and quantitatively using the number of modal options that offer competitive transportation services, the availability of intermodal connections, and the frequency of service (number of departures). A greater number of competitive modal options is considered a benefit because it increases the diversity, redundancy, and flexibility of the overall transportation system and provides travelers with greater choices.

- *Modal options* are a measure of the intercity modal diversity of each of the alternatives.
- An *intermodal connection* or facility allows passengers to transfer from one mode to another to complete a trip. A connection can be as simple as a timed connection between a train and a bus or as elaborate as the BART connection to SFO where air, rail, and bus all converge to give multiple transportation options.
- *Frequency* is measured as the number of departures available to travelers in the study area. High service frequency benefits travelers because it increases the number of possible connections to different modes and the number of options available for travel to a destination.

Modal Options: The No Project Alternative provides four modal options: automobile, air, intercity rail, and intercity bus. However, intercity travel in California is dominated by automobile and air transportation. The automobile accounts for over 88% of all intercity trips, with air transportation representing more than 10% and conventional rail carrying most of the remaining trips. Although the automobile and air modes compete against one another for the longer-distance intercity trips, such as San Francisco to Los Angeles, the automobile is without rival for many intermediate intercity trips. Table 3.2-12 shows intercity trips by mode between the major metropolitan regions in the study area. Between the San Francisco Bay Area and the Los Angeles Metropolitan Area, air transportation serves almost 52.5% of the travel market, with the automobile accounts for 47.3%, and conventional rail 0.2%. Only air transportation offers fast enough travel times to compete for the long-distance business travel market. Trips between the Central Valley and either the San Francisco Bay Area or the Los Angeles Metropolitan Area are good examples of intermediate intercity trips. For these markets, the automobile serves 97.3% of the travel market, while air transportation has 1.5% and conventional rail about 1.2%.

Table 3.2-12
1997 Intercity Trip Table Summary[a]

	1997 Base Trip Tables		
Market	**Air**	**Auto**	**Amtrak Rail**
Los Angeles to Sacramento	2,179,140	2,861,527	9,129
Los Angeles to San Diego	407,185	34,870,032	934,322
Los Angeles to San Francisco	9,376,455	8,442,469	36,525
Sacramento to San Francisco	40,797	20,475,524	502,956
Sacramento to San Diego	613,341	736,732	[b]
San Diego to San Francisco	2,417,203	2,387,001	[b]
Los Angeles/San Francisco to Valley Cities	368,805	23,747,021	290,896
Other	250,059	43,157,606	225,434
Total	15,652,986	136,677,910	2,000,351

[a] Air trips in this table are "local" (or true origin/destination) air trips between metropolitan areas. Connect air trips (which are not destined to a city within the corridor), and their potential for diversion to HST were forecast in the previous study using a separate procedure and subcontractor. The diversion to HST of connect trips is small in absolute numbers, and limited to a few shorter distance intercity markets. The previous connect air forecasts of HST ridership are used in this study as appropriate for the applicable Modal or HST Alternative.

[b] Amtrak trips for these markets are essentially zero and are therefore excluded from the table for clarity.

Source: U.S. Department of Transportation, Caltrans, and Charles River Associates, January 2000.

The Modal Alternative would provide additional capacity but no additional modal options beyond those existing or in the No Project Alternative.

The HST Alternative would provide a new intercity, interregional, and regional passenger mode that would improve connectivity to other existing transit modes and airports. HST would bring competitive travel times and frequent and reliable service to the traditional urban centers of the San Francisco Bay Area, Los Angeles Metropolitan Area, Sacramento, and San Diego. It would significantly improve the modal options available in the Central Valley and other areas of the state currently not well served by public transport (bus, rail, air) for intercity trips.

Tables 3.2-13 (low end) and 3.2-14 (high end) show intercity trips by mode between the major metropolitan regions in the study area projected for 2020 with a statewide HST system. Under the low-end or Business Plan assumptions, between the San Francisco Bay Area and the Los Angeles Metropolitan Area, HST is projected to capture at least 43% of the travel market. Air transportation would serve up to 24% of the travel market, the automobile up to 33%, and conventional rail virtually none of the market. For the high-end ridership assumptions, between the San Francisco Bay Area and the Los Angeles Metropolitan Area, HST is projected to capture up to 71% of the travel market, with the automobile as low as 28%, air transportation serving as little as 1%, and conventional rail virtually none of the market. For trips between the Central Valley and either the San Francisco Bay Area or the Los Angeles Metropolitan Area, the automobile would serve nearly 79% of the intercity travel market, while HST would capture nearly all the remaining 21% for the low-end forecasts (nearly 76% automobile trips and 24% HST trips for the high-end forecasts). The HST Alternative would provide similar benefits to other intermediate intercity markets served by the HST system. For longer-distance intercity trips, HST would provide a competitive alternative to driving and flying. For intermediate intercity trips, HST would also be an attractive alternative to driving.

Table 3.2-13
2020 Intercity Trip Table Summary Business Plan Scenario (Low End)

	2020 Business Plan Trip Tables			
Market	**Air**	**Auto**	**Amtrak Rail**	**HST[a]**
Los Angeles to Sacramento	1,132,827	2,720,332	97	3,384,964
Los Angeles to San Diego	20,805	42,023,218	298,843	5,304,220
Los Angeles to San Francisco	6,487,057	8,549,065	162	11,269,050
Sacramento to San Francisco	2,696	26,448,373	351,485	1,690,169
Sacramento to San Diego	745,079	644,200	61	702,630
San Diego to San Francisco	2,820,117	2,191,051	75	2,228,436
Los Angeles/San Francisco to Valley Cities	32,624	54,950,291	50,583	5,153,090
Other	5,286,399[b]	30,179,854	73,545	2,269,543
Total	16,527,605	167,706,384	774,851	32,002,103

[a] Low-end Business Plan ridership forecast.
[b] Other trips—connecting air trips from outside of the state.

Table 3.2-14
2020 Intercity Trip Table Summary Sensitivity Analysis Scenario (High End)[a]

	2020 Business Plan Trip Tables			
Market	**Air**	**Auto**	**Amtrak Rail**	**HST[b]**
Los Angeles to Sacramento	29,070	3,176,209	97	6,141,554
Los Angeles to San Diego	1,393	50,373,405	298,843	7,444,541
Los Angeles to San Francisco	287,089	9,503,243	162	24,338,901
Sacramento to San Francisco	2,546	30,853,989	351,485	2,246,588
Sacramento to San Diego	60,065	707,496	61	1,749,001
San Diego to San Francisco	177,361	2,315,668	75	6,609,892
Los Angeles/San Francisco to Valley Cities	7,636	64,680,617	50,583	7,228,074
Other	5,277,019[c]	34,315,568	73,545	2,638,702
Total	5,842,178	195,926,194	774,851	58,397,253

[a] Air trips in Tables 3.2 13 and 3.2 14 are "local" (or true origin/destination) air trips between metropolitan areas. Connect air trips (which are not destined to a city within the corridor), and their potential for diversion to HST were forecast in the previous study using a separate procedure and subcontractor. The diversion to HST of connect trips is small in absolute numbers, and limited to a few shorter-distance intercity markets. The previous connect air forecasts of HST ridership are used in this study as appropriate for the applicable Modal or HST Alternative.
[b] High-end Business Plan ridership forecast.
[c] Connecting air trips from outside of the state.
Source: Charles River Associates, January 2000.

Intermodal Connections: The automobile can be used to go virtually anywhere in California. Unlike common carrier transportation modes (air, bus, or rail), the automobile does not require or depend upon intermodal connections to get from the trip origin to the trip destination. The automobile mode would have the same flexibility in the Modal Alternative and the HST Alternative.

Scheduled airline service allows a traveler to reach any destination served by commercial airlines in a relatively short travel time. Unlike the automobile, commercial air travel requires intermodal connections to get to the airport and to a final destination. Moreover, airports are predominately located outside major city centers, a considerable distance from the major transit hubs, which are typically downtown. With the exception of the San Francisco and Burbank airports, which are served directly by rail, all airports in California require transfers to automobiles or road-based public transportation.

It is assumed that there would be limited new intermodal connections under the No Project and Modal Alternatives because a limited number of these improvements are currently planned and programmed.

HST stations would be generally located at existing transportation centers that can serve a wider area through public transit and would enhance intermodal connections in each region. HST stations in the traditional urban cores of the Sacramento, San Francisco Bay, and Los Angeles areas would connect to the heart of the established public transit networks. For example, Los Angeles Union Station (LAUS) is projected to be the most heavily used HST station. LAUS is the transit hub of Los Angeles County and is the primary destination for the Metrolink Commuter rail services, the Los Angeles Metro Red Line, the Pasadena Gold Line, the Amtrak Surfliner service, and the regional bus transit services. The potential station at the Transbay Terminal in San Francisco would be located in the heart of San Francisco's financial district and within walking distance of all major downtown hotels, the convention center, and Union Square retail. The Transbay Terminal would also serve Caltrain commuter rail, all the major bus services to downtown San Francisco, BART, and the extensive San Francisco Municipal Railway (Muni) light-rail system.

HST could have a profound effect on the Central Valley and on outlying areas that are not currently well served by other forms of public transportation. HST would provide convenient and reliable connections to the airports and downtowns of San Francisco and Los Angeles, and to Central Valley cities. All of the potential HST station sites in the Central Valley would either be in city centers or at transportation hubs (airports and Amtrak stations).

<u>Frequency</u>: The automobile, by offering unlimited potential frequency and because it can be driven at virtually any time and to virtually any destination, has the highest connectivity of any mode.

Although 17 commercial airports are included in this study, the range of city pairs served is considerably narrower because little to no commercial service exists between some of the city pairs. Air travel is market-driven and consequently airlines concentrate their operations on markets that are profitable. The San Francisco Bay Area to Los Angeles Metropolitan Area corridor is the most heavily traveled air corridor in the world. This intercity travel market and the long distance markets to/from Sacramento and to/from San Diego have many daily departures and arrivals. In other regions such as the Central Valley, where demand is lower and the distances shorter, the number of daily flights serving California intercity markets is far more limited. Table 3.2-15 shows the daily 1997 average air frequencies by airport pair (Charles River Associates, Inc. 2000). While LAX had service to eight airports within the study area with over ten flights daily in each direction, Fresno had only two (Los Angeles and San Francisco) and Bakersfield only one (Los Angles). Merced, Modesto, Stockton, and Visalia had virtually no air service within the study area.

The additional air transportation capacity provided by the Modal Alternative would likely result in frequency increases between the airports where improvements were made. In particular, based on the assumptions for the Modal Alternative, air service between Fresno and the major metropolitan areas (Sacramento, the San Francisco Bay Area, Los Angeles, and San Diego) could be significantly improved.

The HST system adds a new intercity service to the statewide intercity transportation network that would offer a variety of services with different stopping patterns (express, skip-stop, and local services) to serve long-distance, intermediate, and shorter-distance intercity trips. Consequently, HST would increase frequencies for some city pairs that are not well served by air transportation. In addition to the major city pairs, smaller cities in the Central Valley and suburban cities surrounding the major markets would be directly connected with frequent intercity service.

Table 3.2-15
Daily 1997 Average Air Frequencies by Airport Pair (Each Direction)[a,b]

	BFL	BUR	CLD	FAT	LAX	MCE	MOD	MRY	OAK	ONT	SAN	SCK	SFO	SJC	SMF	SNA
Bakersfield																
Burbank	0															
Carlsbad	0	0														
Fresno	0	4	0													
Los Angeles	19	0	13	30												
Merced	0	0	0	1	0											
Modesto	0	0	0	0	0	0										
Monterey	0	0	0	0	20	0	0									
Oakland	0	15	0	0	35	0	0	0								
Ontario	0	0	0	4	15	0	0	0	12							
San Diego	0	6	0	3	76	0	0	0	11	0						
Stockton	0	0	0	0	0	0	0	0	0	0	0					
San Francisco	5	13	0	17	49	2	5	15	0	8	25	0				
San Jose	0	8	0	0	27	0	0	0	1	7	14	0	0			
Sacramento	3	10	0	2	13	0	0	0	0	10	11	0	20	0		
Orange County	0	0	0	4	17	0	0	3	13	0	1	0	10	14	5	
Visalia	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0

[a] Three-digit codes for airports used as the column headings correspond to the airport names in the row headings.
[b] Data for this table has changed considerably since 1997. For example, there are currently 18 non-stop flights between Los Angeles and Fresno, and seven between San Francisco and Fresno.
Source: Official Airline Guide online database, with calculations by Charles River Associates.

The proposed HST system would serve about 20 to 30 stations (depending on alignment option selected). Table 3.2-16 shows the number of daily trains (for each direction) served for each station pair as assumed for the Business Plan. This table shows that, compared to air transportation, the addition of HST service would greatly increase the number of trains serving major and intermediate destinations. For example, Fresno is expected to have service to 20 stations/cities with frequencies of at least 10 trains daily in each direction, while Bakersfield would have service to 19 stations/cities with frequencies of at least 10 trains daily in each direction. Central Valley cities such as Merced, Modesto, Stockton, and Visalia as well as additional urban markets in the San Francisco Bay Area and southern California such as East San Gabriel Valley, Palo Alto/Redwood City, Riverside, Sylmar, and Escondido, would all receive frequent service to all HST stations.

Table 3.2-16
2020 High-Speed Train Frequencies by Station Pair (Each Direction)

	S.D.	M.M	ESC	TEM	RIV	ONT	E.S.G.	L.A.	BUR	SYL	BAK	TUL	FSN	L.B.	GIL	S.J.	R.C.	SFO	S.F.	MER	MOD	STK	SAC
San Diego																							
Mira Mesa	39																						
Escondido	39	39																					
Temecula	39	39	39																				
Riverside	39	39	39	39																			
Ontario	39	39	39	39	39																		
East San Gabriel	39	39	39	39	39	39																	
Los Angeles	52	39	39	39	39	39	39																
Burbank	31	31	31	31	31	31	31	34															
Sylmar	31	31	31	31	31	31	31	34	34														
Bakersfield	30	22	22	22	22	22	22	33	21	21													
Tulare Co	11	11	11	11	11	11	11	11	12	12	12												
Fresno	25	17	17	17	17	17	17	28	14	14	28	12											
Los Banos	7	8	8	8	8	8	8	8	8	8	8	8	10										
Gilroy	20	20	20	20	20	20	20	23	23	23	12	8	11	10									
San Jose	28	22	22	22	22	22	22	33	23	23	20	8	19	10	25								
Redwood City/Palo Alto	20	20	20	20	20	20	20	23	23	23	12	8	11	10	25	25							
SFO	20	20	20	20	20	20	20	23	23	23	12	8	11	10	25	25	25						
San Francisco	36	26	26	26	26	26	26	46	23	23	21	8	19	10	25	35	25	25					
Merced	4	4	4	4	4	4	4	4	4	4	4	4	4	4	9	9	9	9	9				
Modesto	8	5	5	5	5	5	5	8	4	4	8	4	8	9	9	9	9	9	9	13			
Stockton	13	10	10	10	10	10	10	13	9	9	10	4	11	9	9	9	9	9	9	13	17		
Sacramento	16	13	13	13	13	13	13	9	9	10	11	4	11	9	9	18	9	9	18	13	17	22	

Source: High Speed Rail Authority's final business plan 2000.

Alternatives Comparison for Connectivity
No Project Alternative: Under the No Project Alternative, there would be no net improvement to the connectivity options in the state over the existing conditions. There would no new modes introduced, no new intermodal terminals or connections, and no improvements in air transportation frequencies.

Modal Alternative: Under the Modal Alternative, there would be significant capacity improvements to the air and highway system, but no new modes introduced into the system or intermodal facilities. The additional air capacity would likely result in additional frequencies between the airports where improvements were made. In particular, based on the assumptions for the Modal Alternative, air service between Fresno and the major metropolitan areas (Sacramento, the San Francisco Bay Area, Los Angeles, and San Diego) could be substantially improved where capacity exists.

High-Speed Train Alternative: The HST Alternative would add a new mode to the state's intercity transportation system. The HST would create a variety of new intermodal connections to local, regional, and intercity modes. The HST would add frequencies to the state's intercity travel network, allowing greater flexibility in travel time and location; however, this alternative could result in some decreases in air frequencies in some markets. Of all the alternatives, the HST Alternative provides the highest level of connectivity in the study area, particularly between the Central Valley cities and the city centers of the major metropolitan areas.

Sustainable Capacity
Sustainable capacity is a measure of the transportation capacity of an alternative to meet not only the projected demand but to provide a sustainable capacity over time without the need to develop additional infrastructure. Sustainable capacity is quantitatively measured by the amount of additional transportation infrastructure required to accommodate potential future demand beyond the demand forecast for this system.

For this analysis the design demand is assumed to be the 283 million annual intercity trips by 2020,[10] and both the Modal and HST Alternatives have been developed to accommodate this demand. To test the sustainable capacity of the Modal and HST Alternatives, a theoretical system capacity to accommodate potential additional demand was identified. For the purposes of this analysis, the system capacity is assumed to be approximately 31,500 passengers per hour, which represents a reasonable capacity for a 2-track HST system.[11] The ability of any of the alternatives to accommodate the hypothetical capacity is evaluated by region in terms of capacity on intercity transportation facilities (i.e., 31,500 passengers per hour on the intercity highway segments, airports, or HST for the Bay Area to Merced region) and used as a benchmark to compare the sustainable capacity of No Project, Modal, and HST Alternatives. A description follows of how the theoretical sustainable capacity was developed for each mode and for each alternative.

Highway Mode Characteristics: The sustainable capacity of a highway facility depends largely on the availability of travel lanes and the speed that autos are able to travel. This relationship is expressed as LOS, which is defined in Section 3.1, *Traffic and Circulation*. While all modes are

[10] This demand includes the baseline demand of 215 million annual intercity trips and the 58 million high-end representative intercity demand trips. Not included in this analysis are 10 million commute trips.

11 The figure 31,500 represents 75% of 42,000 passengers per hour. The 42,000 passengers per hour is based on a train separation of 3 minutes between trains and a train capacity of about 1,050 passengers per train for both directions on a double-track system. Trains could be designed with more seating and can accommodate standing passengers if needed and therefore could exceed 42,000 passengers per hour.

subject to capacity constraints that affect the vehicle's speed, given the small capacity of most automobiles (five passengers), more vehicles are required to accommodate a large passenger demand. To meet a higher travel demand, automobiles have two basic options for increasing capacity.

- Vehicle size may be increased (buses): the higher the capacity of the vehicle, the more passengers can be carried at a high rate of speed, and this assumes or requires a change in typical driver behavior.
- Capacity of the roadway may be increased (highway expansion): the addition of lanes allows more autos to travel safely with sufficient stopping distance.

The capacity of an intercity highway lane has been assumed to be 2,300 vehicles per hour with an average auto occupancy rate of 2.4 passengers per intercity vehicle trip, or about 5,520 intercity passengers per hour per lane per direction. Under the No Project and Modal Alternatives, where travel demand is split primarily between the auto and air modes, the highway demand would be 86%[12] of the total 31,500 passengers per hour, or approximately 27,100 passengers per hour in two directions (or 13,500 passengers per direction). Based on an average intercity vehicle occupancy rate of 2.4 passengers per vehicle, 13,500 passengers per direction is equivalent to an additional 5,600 vehicles per direction in addition to the future 2020 peak hour traffic demand. To accommodate the theoretical system capacity, on average[13] every highway link in the study area in all regions would require three additional highway lanes in each direction above and beyond what is proposed under the No Project Alternative. For the Modal Alternative, two additional highway lanes in each direction above and beyond what is proposed would be needed to accommodate the theoretical system capacity. No additional lanes would be required for the HST Alternative because the additional travel demand could be shifted from the highway system to the HST system.

Air Mode Characteristics: The sustainable capacity of an air travel system depends on both the airport and the aircraft. The capacity of an airport includes both airside (e.g., terminals, gates, runways, taxiways, and airspace) and landside (e.g., curbsides, roadways, and parking spaces) systems and facilities. Typical commercial aircraft can range between small jets such as regional jets and Boeing 737s with passenger capacities of 20 to 135, and large jets such as Boeing 777s and 747s with passenger capacities of 200 to 350. As presented in Chapter 2, *Alternatives*, this analysis assumes the Boeing 737 with a seating capacity of 135 will be the typical aircraft used for the intercity market within California.

It is possible to increase the capacity of the air travel system either by increasing the capacity of individual aircraft or by using more small aircraft and by expanding airports. However, for the air travel system to function properly, all systems must be in balance to avoid bottlenecks and unnecessary congestion. For instance, while it is possible to use larger aircraft at all of the airports considered in this analysis, it is necessary that the airside and landside systems be sized to adequately accommodate the additional demand.

Average runway and gate capacity was used to estimate the sustainable capacity of airports. Determining peak-period runway capacity typically requires sophisticated computer simulation techniques and considers the number of runways and their physical relationship to each other for each airport (crossing runways have less capacity then parallel runways, and capacity is further

12 Based on mode splits forecast for 2020 conditions by Charles River Associates 2000.

13 Some areas, such as along I-5 between Bakersfield and Los Angeles, did not require additional lanes, as two lanes per direction would be added under the Modal Alternative; others, such as SR-58 and SR-14, required two additional lanes.

reduced during inclement weather), and the aircraft types that operate during the peak period. Consistent with the approach used for the Modal Alternative, the same ratios (i.e., 525,000 passengers per gate per year and 30 gates per runway) were used to calculate the additional gates and runways required to accommodate the theoretical demand. Similar to estimating the number of highway trips, the total number of air trips are estimated at 4,100 air trips per hour per region, based on the forecasted mode split of 13% of air trips[14] (see Chapter 2).

The addition of 4,100 peak hour trips to each of the regions would require, on average, 51 gates and one runway in each region in addition to the improvements proposed under the Modal Alternative.[15] However, since major urban areas such as the Los Angeles region and the Bay Area have several airports with multiple gates and runways, it is reasonable to expect that those regions could accommodate some of the peak demand with operational improvements. Since interstate and international flights are also competing for the additional slots, any growth in intrastate flights would require additional gate and runway capacity improvements. In the regions with fewer airport options such as the Northern and Southern Central Valley and San Diego, where the gate and runway capacity simply does not exist, additional gates and runways would be needed above and beyond the Modal Alternative's additions. No additional gates or runways would be required for the HST Alternative because the shift of demand from the air system to the HST system would allow airports to handle the peak demand without additional capacity.

<u>High-Speed Train Mode Characteristics</u>: Sustainable capacity of an HST system is determined by the attributes listed below.

- Capacity of rail line (e.g., single track or double track).
- Capacity of the train (number of trainsets, or locomotives and coaches).
- Capacity of stations and passenger facilities, and the lengths of platforms.
- Speed at which the train can travel.
- Train control system.
- Degree that shared-use track is used by other services, thereby reducing available capacity of the HST.

The HST Alternative is a double-track system that allows trains to travel in each direction without having to stop to meet and pass each other. The HST Alternative also incorporates off-line stopping tracks at stations, allowing through trains to pass local trains. The double-track system could sustain a theoretical line capacity of 31,500 passengers per hour without any additional guideway; however, the size and number of trains operating per hour would increase, and the support facilities (e.g., maintenance and storage yards and stations) may have to be sized accordingly. The HST line capacity of 31,500 passengers per hour is based on the design characteristics of the proposed HST system and the following assumptions.

- Trains will be separated by 3 minutes.

[14] Based on mode splits forecast for 2020 conditions by Charles River Associates 2000.

[15] Based on 4,100 passengers per hour, multiplied by an 18-hour operating day, multiplied by 365, which equals 26,937,000 annual trips.

- The capacity of a train will be about 1,050 passengers with a load factor of 75%.
- Traffic will reach 40 trains per hour (both directions on a double track system).

Train capacity can vary depending on the number of cars and how the seats are configured in those cars. The trains can even accommodate standees if the demand exceeds seating capacity. Station platforms need to be the same length as the total length of the train. In this case the train and platforms are designed for a maximum length of more than 1,300 ft (400 m). The train control system is one of the ultimate determinants for speed on the train system, and is assumed to be adequate for the additional capacity (Nash 2003). The train control system is responsible for safely spacing the trains so that there is adequate stopping distance between the trains. While the train control system requirements will determine the ultimate safe traveling speed for the train, the design speed of the train also affects the capacity of the system as a whole. All of these factors play a role in determining the sustainable capacity of an HST system.

In California, conventional rail largely depends on the capacity of the host railroads, which are primarily freight railroads and commuter rail authorities. Amtrak, the current intercity operator, does not own any tracks or have dispatch control in the state. Since conventional rail, especially intercity passenger rail, is a tenant on the host railroads, the ultimate capacity of the line is not in their direct control. Infrastructure conditions, freight demand, and commuter rail demand all play a role in determining the capacity of the railroad. Currently there are considerable capacity constraints in southern California in the Los Angeles area and between Sacramento and San Jose in the Bay Area. Because of these severe capacity constraints in the state, conventional intercity passenger rail has very limited sustainable capacity.

Alternatives Comparison for Sustainable Capacity

No Project Alternative: There is little to no sustainable capacity in the No Project Alternative. The future transportation infrastructure is severely constrained by the limited number of capacity improvements funded or programmed for 2020. Improvements associated with the No Project Alternative are generally to existing interchanges versus line capacity expansion or improvement projects. The highway system's sustainable capacity would require additional infrastructure to accommodate any growth in demand. To accommodate the theoretical system capacity of 31,500 passengers per hour, the highway system would require at least three additional lanes in each direction. The capacity of airports would have to be expanded somewhat more than improvements contemplated under the Modal Alternative. Therefore, the No Project Alternative would not accommodate the theoretical demand and would require extensive infrastructure expansion to have sustainable capacity.

Modal Alternative: There is insufficient capacity in the Modal Alternative to accommodate the additional theoretical demand in all regions. Additional highway and airport infrastructure beyond the Modal Alternative improvements would be required to accommodate the 31,500 peak passenger demand theoretical system capacity. While the Modal Alternative would include some excess highway and airport capacity in the potentially modified highway and airport system, it would not be sufficient in all areas to meet the additional demand and overall service levels would be degraded with use beyond the representative demand. Where the Modal Alternative would provide excess capacity (e.g., capacity gained through addition of a full lane), the capacity would probably be absorbed by other travelers (e.g., commuter or other trips). Additional capacity for highways and airports might be further increased with either higher auto occupancy rates or larger aircraft, respectively. However, auto occupancy rates are not likely to change on a statewide level.

Likewise, the prevailing trend in the aviation industry and projections for future aircraft operations are toward a greater reliance on small and regional jet aircraft (up to 135 passengers) compared to large aircraft for the short-haul intercity travel market under evaluation for this study. Additionally, if larger aircraft were used, landside improvements would still be required to accommodate demand. In both cases, it is important to note that without capacity increases through either lane widenings or additional runways and gates, service levels would worsen for both modes because in both cases performance is contingent on available capacity.

High-Speed Train Alternative: The HST Alternative would provide a train system with sufficient infrastructure to meet the projected demand and to allow for capacity expansion beyond the design year requirements. It would provide an additional mode for the state's intercity transportation system, effectively creating a capacity release valve for the existing intercity modes. The ultimate capacity of the HST could exceed the forecasted 20- to 40-year demand by increasing frequency of service, adding cars to trainsets, using double-deck passenger cars or linking multiple trainsets together on the proposed dual-track system. In addition, the HST Alternative presents a reasonable alternative to expanding highway and aviation infrastructure. Compared to the No Project and Modal Alternatives, the HST Alternative would require no additional infrastructure (with the exception of rolling stock, stations, and maintenance facilities) to provide substantially additional capacity; therefore, the HST Alternative would have the highest sustainable capacity.

Passenger Cost

Passenger cost is a measure of the relative differences in travel costs between the No Project, Modal, and HST Alternatives. Passenger cost for this analysis means the total cost of the trip, including the cost of traveling to the airport or station, the airplane or train fare, and other associated expenses. Cost is one of the key factors that can influence passenger choice of modes.

There is a range of existing intercity travel options, from relatively inexpensive intercity bus to premium air. For example, the cost of traveling round-trip between Los Angeles and San Francisco (one of the busiest travel corridors in the world) can be as little as $25 for an intercity bus ticket to as much as $350 for a walk-up fare for airline travel. The air travel market particularly features large variations in fares. Sources of these variations include the following factors.

- Time of travel: Peak-period travel tends to be more expensive, and Saturday night stays tend to be less expensive.
- Time of booking: Early bookings tend to be less expensive, while last-minute bookings are more expensive.
- Airport choice: Travel between major destinations such as Los Angeles and San Francisco boasts a variety of options and fares, while travel to or from smaller airports with limited service such as Fresno and Bakersfield have greatly limited fare and travel choices.

Passenger cost is quantitatively measured by actual costs to the passenger associated with a typical door-to-door trip. The representative city pairs presented in the travel time discussion earlier in the section are used as a basis to compare the relative differences in cost

Automobile Mode Characteristics: For highway travel, it is assumed that the entire door-to-door trip is made with a private automobile and that there are no ancillary access costs. Automobile travel costs are shown as the total costs per passenger and per auto. The total costs of owning and operating a vehicle include depreciation, maintenance, repairs, taxes, insurance, etc. and are shown on a per-auto basis in Table 3.2-17. The ridership and revenue estimates for the Business Plan are based on the perceived costs of making an automobile trip (e.g., fuel) and do not include all of the true costs associated with owning and operating a vehicle.

Table 3.2-18 summarizes the costs for making a one-way trip for the representative city pairs. Parking is not included even though this could be an additional significant expense. (All-day parking in downtown San Francisco or Los Angeles can be as high as $25.) As shown in the table, the door–to-door average perceived one-way cost per person for traveling between representative city pairs by highway range from $15 to $48 per passenger, and $25 to $81 for total costs.

Table 3.2-17
Auto Ownership and Operating Costs by Category (2003$)[a]

Cost Category	Percent of Cost	Cents
Financing	15	7.7
Depreciation	35	18.0
Fuel Tax	4	2.0
Fuel	9	4.6
Repairs	2	1.0
Maintenance	5	2.6
State Fees	3	1.5
Insurance	27	13.8
Total	100	51.2

[a] All costs escalated by 3% for 3 years to calculate 2003 dollars.
Source: Federal Highway Administration, Our Nation's Highways, 2000.

Table 3.2-18
One-Way Door-to-Door Trip Automobile Costs (2003$)[a,b]

City Pair	Average Total Cost per Passenger[c]	Total Costs per Auto[d]
Los Angeles downtown to San Francisco downtown	$81	$194
Fresno downtown to Los Angeles downtown	$47	$112
Los Angeles downtown to San Diego downtown	$25	$61
Burbank (airport) to San Jose downtown	$70	$169
Sacramento downtown to San Jose downtown	$25	$60

[a] California High Speed Rail Authority Business Plan cost numbers. HST ridership forecasts assumed only perceived auto costs. Average cost does not include parking.
[b] All costs escalated by 3% for 3 years to calculate 2003 dollars.
[c] Total cost based on average cost of owning and operating a vehicle of 51 cents per mile divided by the assumed average auto occupancy rate of 2.4 persons. Source: Federal Highway Administration, Our Nation's Highways, 2000.
[d] Full cost of driving a single-occupant auto based on average cost of owning and operating a vehicle of 51 cents per mile.
Source: Federal Highway Administration, Our Nation's Highways, 2000; Parsons Brinckerhoff 2003.

Air Mode Characteristics: The passenger cost of air travel is primarily determined by the available fare. Depending on the airport, airline, time of year, day of the week, and even certain hours of the day, the price of an air ticket can vary greatly. Regions with competing airports or alternative sub-markets (i.e., Ontario and Oakland) have more fare, schedule, and airline options compared to airports with limited service (e.g., Fresno and Bakersfield). In California, since most air operations are scheduled to serve longer distance markets, some major airports such as San Francisco and Los Angeles have a more limited choice of airlines and fare options for intra-California travel. Airports that provide more limited service, such as Fresno and Bakersfield, typically have only a few flights available per day and typically one or two airlines that serve that market. However, airports like Ontario and Oakland have frequent intra-California flights from a range of airlines at highly competitive fares.

Average total air costs were calculated as including access, egress, and airfare costs. The access and egress sum cost ranges from $10 to $24 per trip. Air trips require at least one other mode to travel from a different location (e.g., home/office) to the airport, which may include public transit (bus or rail), taxi/shuttle, or private auto (may require parking or drop-off).

A range of airfares are available that depend on time of purchase (e.g., 21-day advance purchase versus same-day fare), duration of visit (e.g., same-day or Saturday night stay), and departure time (e.g., peak versus off-peak). Table 3.2-19 summarizes the average total cost for air travel between city pair destinations based on the Business Plan estimates (escalated to 2003 dollars). As shown, airfares vary widely and can range from $94 between Burbank and San Jose to $224 between Sacramento and San Jose.[16]

Table 3.2-19
Average One-Way Door-to-Door Air Trip Passenger Costs (2003$)[a]

City Pair	Average Total Costs[b]
Los Angeles downtown to San Francisco downtown	$148
Fresno downtown to Los Angeles downtown	$193
Los Angeles downtown to San Diego downtown	$148
Burbank (airport) to San Jose downtown	$94
Sacramento downtown to San Jose downtown	N/A

[a] Based on low-end revenue and ridership forecasts from the Business Plan. Costs are escalated by 3% for 3 years.
[b] Sample costs include fares as well as parking, taxi fares, and other costs involved with traveling to and from the airport.
Source: Parsons Brinckerhoff 2003.

High-Speed Train Mode Characteristics: Similar to air travel, the primary cost associated with HST travel is the cost of the train ticket. For this analysis, the fare schedule identified in the Business Plan (escalated to 2003 dollars) was used to compare the representative city pairs (Table 3.2-20). However, based on experience in Asia and Europe, HST fares may vary the way airfares do with the time of year, day of week and duration of stay. New competition may also develop between the different modes that may affect HST fares. The HST could also offer premium and economy services with corresponding fares depending on the markets that develop.

As with air travel, both an access and egress fee of about $5 or $6 ($10 to $12 total) are part of the HST average total costs. HST travel requires at least one mode change to access the nearest HST station. Because the HST stations are generally located in the city centers they are assumed to be located in closer proximity to larger population and work centers than airports. The HST

[16] There is no direct air service between Sacramento and San Jose; therefore it is assumed that this trip would be between SMF and SFO with a shuttle connection to San Jose.

line-haul travel fare was estimated by using the fare schedule presented in the Business Plan (escalated to 2003 dollars).

Table 3.2-20
High-Speed Train One-Way Door-to-Door Trip Passenger Costs (2003$)[a]

City Pairs	Average Total Cost[b]
Los Angeles downtown to San Francisco downtown	$59
Fresno downtown to Los Angeles downtown	$50
Los Angeles downtown to San Diego downtown	$47
Burbank (airport) to San Jose downtown	$52
Sacramento downtown to San Jose downtown	$48

a Based on business fare costs provided in Business Plan.
b Sample costs include fares as well as parking, taxi fares, and other costs involved with traveling to and from the airport.
Source: Parsons Brinckerhoff (2003).

Depending on city pair, level of state support for fare subsidies, and competition, intercity passenger rail would be cost-competitive with the HST. On average, given current fares for Amtrak service and the proposed fares for HST, conventional intercity service would cost approximately 10% less than the HST for the representative city pairs listed above (assuming the same access and egress fees as the HST). Conventional rail would also be considerably less expensive than air based on the representative city pairs.

<u>Alternatives Comparison for Passenger Costs</u>
<u>No Project Alternative</u>: Overall, auto passenger costs are considerably lower for short- and mid-range trips than airfares for short haul routes, such as Los Angeles to San Diego, Los Angeles to Fresno or Sacramento to San Jose. For long-range trips, such as Los Angeles to San Francisco or Burbank to San Jose, the automobile remains competitive due to the access and egress costs associated with air travel.

<u>Modal Alternative</u>: Because no additional mode options are included in the Modal Alternative, passenger costs would be, on average, equal to those of the No Project Alternative. The same passenger cost analysis of short-, mid-, and long-range trips of the No Project Alternative pertains to the Modal Alternative.

<u>High-Speed Train Alternative</u>: The HST Alternative would provide an overall passenger cost savings for all city pairs analyzed. On average, the HST Alternative could save from 8% to 44%, depending on city pair, of the passenger costs associated with the No Project and Modal Alternatives. The HST mode is cost-competitive with the highway mode for all trips and is less expensive than the air mode. For all city pairs, the HST Alternative provides a price-competitive alternative to existing airline service and the automobile.

3.2.4 High-Speed Train Alignment Options Comparison

Travel time, connectivity and passenger cost for the HST can all be affected by which alignment option the HST travels on. This section discusses the relative differences by region of the alignment options for the HST Alternative.

A. BAY AREA TO MERCED

The selection of the Diablo Range direct options between the San Francisco Bay Area and the Central Valley would have significant implications for HST service. The Diablo Range direct alignments are a shorter and faster option between the San Francisco Bay Area and Sacramento/Northern San Joaquin Valley, providing for much shorter travel times between these markets. For example, for express trains between Sacramento and San Jose, the Diablo Range direct alignments travel times would be about 25 min less than for the Pacheco Pass (50 min for the Diablo alignments verses 1 hr and 15 min for the Pacheco Pass options). The Diablo Range direct options would permit express travel times between Sacramento and San Francisco in 1 hr and 20 min, compared to 1 hr and 45 min via the Pacheco Pass options.

The Diablo Range direct alignments would place Merced on the San Francisco to Los Angeles segment of the HST network, which would result in a higher frequency of service to/from Merced. However, the Pacheco Pass alignment options include potential stations at Gilroy (or Morgan Hill) and Los Banos, whereas the Diablo Range alignments do not have any stations between Merced and San Jose. The populations that would be served by the Gilroy and Los Banos stations would therefore have much shorter access times and access costs to the nearest HST station with the Pacheco Pass alignments. The potential Gilroy/Morgan Hill Station would have a particularly high impact on connectivity, travel times, and access costs, since in addition to serving Southern Santa Clara County, it would also be the most accessible station location for serving the Santa Cruz, Monterey/Carmel, and Salinas populations.

The decision on how best to serve the Bay Area cities would also have a major impact on the HST system. This Program EIR/EIS evaluates both potential service to the Bay Area along the San Francisco Peninsula and potential service along the East Bay to Oakland. If service to both sides of the Bay were pursued, service to each Bay Area station (north of San Jose) would be less frequent. However, if only one side of the Bay were directly served by the proposed HST system, the number of intermodal connections would be greatly reduced. The access times and access costs would increase significantly, and the competitiveness of the new mode on the side of the Bay not served would also be reduced. For example, if the East Bay is not directly served, all trains bound for the Bay Area would terminate in downtown San Francisco. However, there would be no HST link to directly serve Oakland, the Oakland Airport, or Southern Alameda County. Potential HST passengers from the East Bay would have to either use the Capitol Corridor, mass transit, or drive to San Francisco, San Jose, or the Peninsula to use the HST service.

The I-880 alignment would provide superior travel times to connect the HST system to the East Bay as compared to the Hayward/Niles/Mulford Line. The Mulford Line is a longer route and has tight curves that would severely restrict speeds between Fremont and Union City. For all potential markets to Oakland, the I-880 corridor would offer express and local travel times of about 6 min less than the Mulford Line. Using the I-880 corridor, travel times between Oakland and Los Angeles could be achieved in 2 hrs and 18 min, whereas using the Mulford Line the same trip would take a minimum of 2 hrs and 24 min.

Potential Station Locations

- For service to downtown San Francisco, the Transbay Terminal and the 4th and King Station were selected for further evaluation. The 4th and King Station is the existing terminus for the Caltrain commuter rail service. This station site (adjacent to Pacific Bell Stadium) is well connected to the San Francisco Muni system but stops more than a mile short of the financial district of downtown San Francisco and does not connect to BART. The Transbay Terminal would offer significantly greater connectivity to San Francisco and the greater Bay Area than the existing 4th and King site due to its location in the heart of the downtown San Francisco financial district, where many potential HST passengers could walk to the station. In addition, the Transbay Terminal would serve as the transit hub for all of the major services to downtown San Francisco, with the advantage of direct connections to BART and Muni. The 4th and King Station would have about a 2.5-min shorter line-haul travel time to San Francisco than the Transbay Terminal, since the trains would travel at relatively slow speeds between 4th and King and the Transbay Terminal, a distance of 1.2 mi (1.9 km). However, since the Transbay Terminal would offer much greater connectivity to San Francisco and the greater Bay Area than the existing 4th and King site, total travel times to downtown destinations via the Transbay Terminal are expected to be superior.

- West Oakland Station and 12th Street City Center Station were selected for further consideration for the Oakland terminus station. Both of these potential stations would directly connect with BART, and both would have good freeway access. The 12th Street City Center Station would have superior connectivity, as it is located in the heart of downtown Oakland where many potential HST passengers could walk to the station. The 12th Street City Center BART Station is also a transfer station providing greater connectivity to the regional rail transit system.
- A potential station to serve San Mateo County would be located either at Redwood City or Palo Alto. Both would be multi-modal stations at existing Caltrain station locations. The Palo Alto Station would be a stop for the Caltrain express services, and therefore would have better connectivity to the regional commuter service and to the Peninsula.
- A potential station to serve Southern Alameda County would be located at either Union City or Fremont (Auto Mall Parkway). Both station locations would offer a high level of connectivity. The Union City Station would connect to BART, the Capitol Corridor, and AC Transit; whereas the Auto Mall Parkway Station would have good access to the I-880 freeway and connect to the Capitol Corridor, ACE Commuter Rail, and AC Transit. The Union City Station site serves both alignment options for East Bay service, while the Auto Mall Parkway site is only served by the Mulford Line alignment.
- South Santa Clara County potentially would be served by a station at either Gilroy or Morgan Hill. Both of these two potential stations would be at Caltrain commuter rail station locations. The Gilroy Station is about 10 mi (16 km) south of Morgan Hill and therefore provides better connectivity, travel times, and lower access costs to the Santa Cruz, Monterey/Carmel, and Salinas markets. The Gilroy Station is only served by the Pacheco Pass/Gilroy/Caltrain alignment, and neither the Gilroy nor the Morgan Hill station sites would be served by the Diablo Range Northern alignment options.
- Four other potential stations are being considered for service to the Bay Area: Diridon Station in downtown San Jose, and stations to serve the three regional international airports, SFO, Oakland (Coliseum BART), and San Jose (Santa Clara). In addition, a potential station in the Central Valley to serve Los Banos is being considered for the Pacheco Pass alignment options. Diridon Station would be a multi-modal hub maximizing connectivity to downtown San Jose and the Southern Bay Area. Diridon Station would serve Caltrain, ACE Commuter Rail, the Capitol Corridor, Amtrak, VTA buses and light rail, and a possible link to BART. None of the three airport stations would be in the airport terminals, but each would permit easy access by people movers, or shuttles (at SFO, BART currently provides a direct connection from the Millbrae Caltrain Station to the SFO international terminal). All three potential airport stations would have direct connections to local and regional commuter rail services and would minimize potential travel times and costs for HST passengers who would use the trains for access to the airports. The potential Los Banos Station would be north of the city of Los Banos with good accessibility to I-5 and would greatly reduce travel times and access costs to that population.

B. SACRAMENTO TO BAKERSFIELD

Between northern and southern California, the UPRR rail alignment is slightly more direct than the BNSF rail alignment, about 4 mi (6 km) less distance when measured from the BNSF and UPRR merge point, which is 2.3 mi (3.7 km) south of the Truxton Station on the BNSF and 3.6 mi (5.8 km) south of Bakersfield Golden State Station on the UPRR. However, since maximum speeds would be achieved throughout the Central Valley, the differences in travel times between northern and southern California would be marginal, with the UPRR providing potential travel times about 2 min less than the BNSF. The UPRR and BNSF rail alignments would serve the same populations and same number of potential stations. Therefore, the selection of the Central Valley alignment would not have an overall impact on Central Valley connectivity. Most of the potential stations locations throughout the Central Valley can be served by either the BNSF or the UPRR, and the preferred Central Valley alignment could even be a combination of these two existing freight rail corridors. The potential Modesto stations and potential station at either Hanford or Visalia are the exceptions, where the selection of the alignment (between Stockton and Merced for the Modesto Station and between Fresno and Bakersfield for Hanford/Visalia) would determine the potential station location since there are no practical connections between the UPRR and BNSF at these locations.

Potential Station Locations

- The Downtown Sacramento Valley Station would have better connectivity in Sacramento than the Power Inn Road Station location. The Valley Station is located in downtown Sacramento and is within walking distance of the state capitol. This multimodal station location serves the existing Amtrak services to Sacramento, including the Capitol Corridor, and will serve the Sacramento Light Rail Train (LRT) that is being extended to this station site. This site also has good access to I-5. Although the Power Inn site has good intermodal access to the Sacramento LRT and to US-50, it is located outside of downtown Sacramento, more than 5 mi (8 km) away from the state capitol. The Power Inn Station would have about a 3-minute shorter line-haul travel time to Sacramento then the Downtown Sacramento Valley Station, since the trains would travel at relatively slow speeds between Power Inn and the Valley Station, a distance of about 7.5 mi (12.1 km). However, the Sacramento Valley Station would offer greater connectivity to downtown Sacramento and the Sacramento region, and shorter total travel times to downtown destinations.

- Two potential station sites are evaluated to serve Modesto: a potential downtown station on the UPRR rail alignment, and the existing Amtrak Briggsmore Station on the BNSF alignment. The downtown station maximizes connectivity to downtown Modesto and provides convenient access to SR-99, whereas the Amtrak Briggsmore Station is about 5 mi (8 km) east of downtown Modesto. As noted above, the selection of the alignment between Stockton and Merced would determine the station site for Modesto.

- To serve Merced, potential station locations are evaluated at downtown Merced along the UPRR alignment, at Castle Air Force Base, and at the Merced Municipal Airport. The downtown station is located near the city center and transit hub of Merced, has good access to SR-99, and would have the highest level of connectivity of the three locations. The Castle Air Force Base site is about 7 mi (11 km) from downtown Merced, but would provide easy access to the developing University of California, Merced campus via a new highway alignment along Bellevue Avenue. The Merced Municipal Airport site would be less than 2 mi (3 km) from downtown Merced.

- Potential station sites in Tulare and Kings Counties are evaluated at Hanford and Visalia. The ultimate selection of an alignment between Bakersfield and Fresno would include the determination of station location. The Hanford site would connect to the Amtrak station in Hanford, whereas the Visalia Airport Station would best serve the more populated Tulare County cities of Visalia and Tulare. The BNSF serves Hanford and would result in faster travel times and lower access costs for Hanford residents and Kings County; the UPRR serves

Visalia and would result in faster travel times and lower access costs for the Visalia population and Tulare County.

- The Truxton Station would have the highest connectivity of the three locations being evaluated to serve Bakersfield. The Truxton Station would connect to the new Bakersfield Amtrak Station and is in the city center of Bakersfield, within walking distance to the convention center and city hall. The Truxton station location also has good access to SR-99. The Golden State Station site is less than 2 mi (3 km) northeast of the city center next to SR-204. The Bakersfield Airport Station would be located outside of Bakersfield about 6 mi (10 km) northeast of the city center. The airport station would provide a high level of connectivity to the airport and has good access to SR-99.
- Two other potential stations are considered for Central Valley service, the ACE Stockton Downtown Station and Downtown Fresno Station. Both of these stations would maximize connectivity to downtown Stockton and to downtown Fresno. The ACE Stockton Station is the current terminus for the ACE Commuter Rail to San Jose and is located in the central part of Stockton. The Downtown Fresno Station is close to the city center and has convenient access to SR-99, SR-41, and SR-180 freeways.

C. BAKERSFIELD TO LOS ANGELES

The selection of the southern mountain crossing alignment option between Bakersfield and Los Angeles would have implications for the HST system and have an effect on the travel times between northern and southern California. The I-5 alignment would have express times about 10 min less than the SR-58/Soledad Canyon alignment, and local times about 12 min less. For example, the San Francisco to Los Angeles express travel time would be less than 2 hrs and 25 min for the I-5 alignment and just over 2 hrs and 35 min for the SR-58/Soledad Canyon alignment. The SR-58/Soledad Canyon alignment option includes a potential station at Palmdale, whereas the I-5 alignment does not have any stations between Bakersfield and Sylmar. The potential Palmdale Station would have a particularly high impact on connectivity since it would serve the growing communities of the Antelope Valley. The SR-58/Soledad Canyon alignment would also improve travel times and reduce access costs to and from the Antelope Valley population.

Between Sylmar and Los Angeles, the combined I-5/UPRR alignment would be shorter and have fewer speed-restricting curves than the UPRR/Metrolink alignment, resulting in travel time saved of about 1 min.

<u>Potential Station Locations</u>

- There are three station sites within the vicinity LAUS: LAUS, Union Station South, and Los Angeles River East. Of the three potential sites, the existing LAUS station has the best connectivity and therefore would also provide the fastest overall travel times to many destinations. LAUS is the transit/rail transportation hub of southern California. LAUS is the primary destination for the Metrolink commuter rail services, the Los Angeles Metro Red Line, the Pasadena Gold Line, the Amtrak Surfliner service, and the regional bus transit services. HST would serve LAUS on an elevated structure where transfers to other modes would be made directly under the HST platforms. The Los Angeles River East Station and Union Station South sites would require the construction of a pedestrian bridge/plaza across the US-101 freeway to connect with LAUS.
- The Palmdale Transportation Center is being considered as a potential station site for serving the Antelope Valley population. The Palmdale Transportation Center maximizes opportunities for intermodal connectivity. It is close to Palmdale Airport, with the opportunity for convenient shuttle or people-mover connections. The transportation center is the Metrolink

Station for Palmdale and is a hub for local bus services. The Palmdale Transportation Center would provide short travel times and low access costs for the Antelope Valley population.

- The Sylmar Metrolink Station would provide a direct connection to the Metrolink regional commuter rail service and would have convenient access to the freeway network.
- The Burbank Metrolink Station would provide the highest connectivity to the Burbank area. This station site is in downtown Burbank, has a direct connection to the Metrolink regional commuter rail service, is a hub for bus transit in the Burbank area, has adjacent access to I-5, and is only 2.4 mi (3.9 km) from Burbank Airport. The Burbank Airport Station would be nearer to Burbank Airport at 1.6 mi (2.6 km) away, but would be outside the city center and does not connect with a Metrolink station or regional transit.

D. LOS ANGELES TO SAN DIEGO VIA INLAND EMPIRE

Between Los Angeles and Riverside, the UPRR Riverside and UPRR Colton rail alignments would serve the same populations and same number of potential stations, whereas the alignment options for either the UPRR Riverside or UPRR Colton that would directly serve the city center of San Bernardino and would offer greater connectivity with freeway, commuter rail, and local transit. Using the San Bernardino alignment would add between 4 min and 8 min to the travel time between Los Angeles and March ARB.

Decisions concerning how a proposed HST system would best serve San Diego would have implications for the HST system and its operations. The Miramar Road and Caroll Canyon alignment options would have considerable connectivity advantages over the Qualcomm alignment option. The Miramar Road alignment and the Carroll Canyon alignment options would directly serve downtown San Diego, while the Qualcomm Stadium Station would be about an 8-mi (13-km) drive or 10-mi (16-km) light rail ride to the city center. In addition, the Miramar Road and Carroll Canyon alignment options would provide an alternative to the potential Mira Mesa Station at University City.

The I-15 alignment to Qualcomm Station would have the shortest line-haul times (about 7 min less than the two options to downtown San Diego), but would not directly serve downtown San Diego. The line-haul time for the LRT between Qualcomm and the downtown San Diego Santa Fe Depot is more than 20 min long. The Miramar Road and Carroll Canyon alignment options would therefore be expected to provide considerably superior total travel times to downtown San Diego than the I-15 alignment to Qualcomm Stadium. Decisions on how best to serve San Diego with a proposed HST system could also impact total HST passenger costs for service to or from San Diego. The Miramar Road and Carroll Canyon alignment options that would serve downtown San Diego would be expected to have lower access costs to downtown San Diego than the I-15 alignment to Qualcomm Stadium.

<u>Potential Station Locations</u>

- Of the four potential stations sites serving East San Gabriel Valley, the Metrolink station sites at Pomona and City of Industry would have the widest range of multimodal connections to local and regional bus services, and to Metrolink commuter rail service. The City of Industry site would provide a more central location between the potential stations at LAUS and Ontario Airport. All of the potential station sites would have good access to the freeway network. The Pomona station area would be served by both the UPRR Colton and UPRR Riverside/Colton alignment options, whereas the El Monte station and City of Industry sites are on the UPRR Colton alignment and the South El Monte station on the UPRR Riverside alignment. The City of Industry site would provide a more central location between the potential stations at LAUS and Ontario Airport and therefore the lowest overall travel times.

- Of the four potential stations sites serving the Riverside/San Bernardino area, the San Bernardino Metrolink Station site would have the widest range of multimodal connections to local and regional bus services and to Metrolink commuter rail service. The UPRR Colton Station site would have the least connectivity to existing transit services, but would have the most central location for serving both the San Bernardino and Riverside populations and have good accessibility to I-10. The University of California, Riverside (UCR) site is furthest away from the freeway network but provides for the most convenient access to Riverside. Service to the San Bernardino Metrolink Station would provide the most convenient access to San Bernardino. The March ARB site would be adjacent to the airport, but would have the least connectivity, longest travel times, and highest access costs since the airport does not serve commercial air passengers and this site is furthest away from the Riverside/San Bernardino populations.
- For service to San Diego, the Downtown San Diego Santa Fe Depot site would have the highest connectivity. This station is located in the city center where many potential HST passengers could walk to their destination. The Santa Fe Depot is the terminus for the Coaster commuter rail service, the Amtrak Surfliner intercity service, provides direct connections to the San Diego LRT network, and is a bus transit hub for San Diego. San Diego International Airport is a unique airport in that is located adjacent to downtown San Diego and is only about 2 mi (3 km) from the city center. The San Diego Airport Station location would provide a convenient connection to the international airport and directly connect with the regional bus network and a San Diego LRT station. Although the San Diego airport location would not have as good connectivity to the city center as the Santa Fe Depot site, it would have a better connection to I-5. Qualcomm Stadium would provide a direct connection to the San Diego LRT network and good freeway access, but it would not have the same level of connectivity to the San Diego city center.
- The Escondido Downtown Transit Center would have somewhat higher connectivity than the Escondido I-15 Station Site. The Downtown Transit Center Station would be closer to the Escondido Transit Center, within 0.13 mi (0.20 km), and provide better connectivity with the proposed Escondido to Oceanside commuter rail service, but the Escondido I-15 site would provide more convenient freeway access.
- The University City station site in San Diego is located near a densely developed portion of San Diego, which could be served by the Coaster commuter rail service, would be served by San Diego LRT, and would provide a higher level of connectivity than the Mira Mesa station location. However, the University City site is not served by the I-15 alignment option that serves the Qualcomm Station.
- Potential stations are also being considered at the Ontario airport and Murietta. The Ontario Airport Station would provide a multi-modal connection to Ontario International Airport and link to region bus transit services. The Ontario Airport Station would provide the fastest HST travel times and reduce access costs for passengers looking to make an air connection at Ontario International Airport. A potential station at Murietta would serve the fast-growing Temecula/Murietta area. The Murietta at I-15/I-215 Interchange Station site would have convenient freeway access to both I-15 and I-215.

E. LOS ANGELES TO SAN DIEGO VIA ORANGE COUNTY

Decisions on how proposed rail improvements may best serve the LOSSAN corridor would have major implications for the HST system and operations. The Authority is considering optional service to LAX and Orange County. If service to LAX and/or Orange County were selected, frequencies to each station along the Los Angeles to San Diego via Inland Empire corridor could be less than if a single line south of Los Angeles were selected. However, if HST directly serves LAX and/or Orange County, the number of intermodal connections could be greatly increased. The travel times and access costs to these markets would be greatly decreased with the HST, and the competitiveness of the HST would be greatly increased for the southwest portions of Los Angeles County and/or Orange County intercity transportation markets. If the airport is not directly served, local transportation (shuttle, regional transit, or the automobile) would be needed between LAUS and the airport or to western Los Angeles County. For the link to Orange County, potential stations are being considered at Norwalk (southern Los Angeles County, serving the gateway cities), Anaheim, and Irvine. If Orange County is not directly served, passengers to southern Los Angeles County and Orange County would need to transfer to non-electric, conventional intercity rail Amtrak Surfliner service at LAUS.

The LOSSAN alignment between LAUS and Anaheim would provide a high level of connectivity with Metrolink, Amtrak Surfliner, and regional and local bus transit. However, because this alignment would require sharing tracks with existing services, it is severely constrained in terms of sustainable capacity and the potential frequency for HST service to Orange County. Operations models suggest that the HST operations may be limited to 18 to 45 trains per day (in each direction) to Orange County if the LOSSAN alignment is selected. In contrast, the UPRR Santa Ana alignment would be dedicated to HST service and would have the capacity to serve up to 20 trains per hour, but it does not provide direct connectivity to Metrolink or Amtrak.

The level of conventional improvements to the LOSSAN corridor south of Irvine would also impact the connectivity of south Orange County communities and the coastal cities of San Diego County. Infrastructure improvements for the Surfliner service could increase the frequency of service for markets south of Irvine, decease the travel times to these markets, and improve the competitiveness of rail transportation as a modal alternative in this corridor.

Potential Station Locations

- South Los Angeles County could have a potential HST station at Norwalk either along the LOSSAN rail alignment or the UPRR Santa Ana alignment. The selection of the alignment between Los Angeles and Orange County would determine the preferred station location for serving the gateway cities of south Los Angeles County. The Norwalk LOSSAN site would be at Norwalk Metrolink Station with direct connectivity to the regional commuter rail service. This site is a bus transit hub for the area and is well served by I-5 and the Imperial Highway. The Norwalk UPRR site has no existing passenger rail connection, as it is located about 1 mi (1.6 km) east of the Green Line LRT terminus, but it has existing bus connections and good freeway access.
- Three other potential HST stations are being considered for the LOSSAN area: a potential station at LAX, and potential stations at Anaheim and Irvine to serve Orange County. The LAX station would be adjacent to the airport terminals and would permit easy access by a potential people mover, shuttle, or by walking. It would have direct connections to regional bus transit services and be the only HST station directly serving western Los Angeles County. The Anaheim Edison Field Amtrak Station and the Irvine Transportation Center are transit hubs with high connectivity for central and south Orange County respectively. These stations are OCTA bus transit hubs and serve existing Amtrak and Metrolink commuter rail services.
- For the non-electric service along the LOSSAN corridor, two additional stations are being evaluated that would increase connectivity and decrease travel times and access costs to portions of San Diego County: the University Towne Centre (UTC) Station and a potential station at San Diego International Airport. The UTC Station site would depend on the selection of the design option to tunnel under UTC to bypass the existing Miramar Canyon rail alignment. UTC is a densely developed portion of San Diego. The station would also be served by the Coaster commuter rail service and potentially could have a direct connection to the regional LRT service. The San Diego Airport Station would provide convenient access to San Diego International Airport.

- The stations currently served by the existing Surfliner service are assumed to continue to receive service with an improved non-electric conventional service between Los Angeles and San Diego. These stations maximize connectivity as established multi-modal hubs with direct connections to local transit and the Metrolink (Los Angeles to Oceanside) and Coaster (Oceanside to San Diego) commuter rail services. Design options are being evaluated at San Juan Capistrano (Trabuco Creek) and San Clemente (long split tunnel and short tunnel) that could move the alignments and the station locations. In both cases, it is most likely that all rail services would utilize and serve the new facilities. The I-5 tunnel bypass concept at San Juan Capistrano would result in decreased connectivity to south Orange County since the bypass would move the existing alignment under I-5 and avoid San Juan Capistrano.